AECV93-R3

Evaluation of Drinking Water Plant at

Elk Island National Park

Astotin Lake - Administration Site

Alberta
ENVIRONMENTAL CENTRE

EVALUATION OF DRINKING WATER PLANT AT ELK ISLAND NATIONAL PARK ASTOTIN LAKE - ADMINISTRATION SITE

by

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We would like to thank all the members of the Park staff who participated in the questionnaires and odour panels, or contributed information through feedback to the operators, General Works Manager and AEC staff.

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ABSTRACT

The Water & Wastewater Technology Research Branch of the Alberta Environmental Centre (AEC) was approached by Public Works Canada to evaluate treatment for the Administration Site water treatment plant on Astotin Lake in Elk Island National Park.

A series of bench and pilot scale experiments, including trials using the water plant as it stood, were conducted between March 1988 and August 1990. Two questionnaires were circulated, and four odour/palatability panels formed, providing information on expectations of consumers and information on the suitability of processes being investigated.

Minor additions and modifications to the physical plant were subsequently suggested by the AEC. These were undertaken by Parks Canada, improving the operations of the plant.

Technologists from the AEC test-operated the plant and found the basic process of clarification and filtration to be sound for this application. Technologists then trained Elk Island operators on proper operating procedures.

Modified operation produced good quality water, but operator attention (and quality of product) deteriorated in the months after direct participation by the AEC was phased out.

Ozonation as an alternative treatment was studied in detail, and was found capable of treating the raw water (in combination with filtration).

Carbon filtration as a polishing step to other processes was found to be advantageous in most cases. The useful life of carbon was determined to be short, reducing the practicality of most types of installations.

All the studied options for treatment showed some degree of odour remaining in the product water, particularly when chlorinated.

It was concluded that the existing Administration Site plant may provide the most practical means of treating Astotin Lake water for consumptive purposes, provided the following steps are taken: further modifications to the clarifier and other parts of the system are made; clearly defined objectives and priority for the operators along with standard operating times are outlined; a person outside normal operations audits the quality control and provides feedback to the operators and supervisors, thus reducing the risk of a deterioration in product quality resulting from less attention paid to the importance of quality control.

A carbon cartridge system may prove practical to polish the product water, reducing residual or chlorine-enhanced odour. Carbon polishing may also reduce the potential of the product water to produce trihalomethanes.

Redesigning the water plant to incorporate ozonation as the primary process would produce quality product water, but such a system would likely still encounter post-chlorination odours similar to those produced by the current process. Operation of an ozonation system could require less total operator time, but would be more technically demanding.

1 INTRODUCTION

The Water & Wastewater Technology Research Branch of The Alberta Environmental Centre (AEC) was approached by Parks Canada to evaluate treatment options of the Administration Site water treatment plant on Astotin Lake in Elk Island National Park. Work done, improvements made and recommendations for the future are contained in this report.

1.1 Early History and Correspondence

In early-1988, Rae Howe of Parks Canada contacted Dr. Albert Van Roodselaar of AEC to express concern about the quality of the water being produced at the Administration Site water treatment plant on Astotin Lake.

The two parties agreed that AEC staff would investigate the problem and do some preliminary testing[1].

Results of bench-scale work done at AEC were presented in a preliminary report[2].

By July 12, 1988, agreement was reached for further work to be done[3]. Contacts between Mr. Howe and Brian Gray (of the AEC), in September and October of 1988, further defined the role of the AEC and the approach to be taken for this work. A letter from R. Howe to B. Gray represents this period of contact[4].

1.2 Outline of Agreed Objectives

An outline of the objectives agreed upon by Parks Canada and the Alberta Environmental Centre follows. This list is a summary derived from the contract signed between the two parties. A copy of the agreement has been included as Appendix 10.4 of this report.

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[1]Appendix 10.1.1, Letter R. Howe to A. Van Roodselaar, Jan. 21, 1988.

[2]Appendix 10.2, submitted to R. Howe, April 22, 1988.

[3]Appendix 10.4, Tender.

[4]Appendix 10.1.3.

Outline of objectives:

(i) Monitor seasonal variation of raw water supply quality. Generally, samples to be taken once per month for two years. Investigate change in intake position; will it be beneficial?

(ii) Do a field study. Use mobile facility to evaluate ozonation, coagulation, filtration and combinations of these processes. Monitor existing plant to determine adaptability to proposed processes. Establish a palatability panel to measure acceptability of process water.

(iii) Present a detailed report. Include current system, filter and coagulation studies and the impact of ozone addition to the system. Based on panel results, determine acceptability of Astotin Lake water with respect to the degree of treatment required.

(iv) If pilot results are positive, suggest process options to enhance operation and product. Suggest changes and additions. Recommend operating instructions based on alternative process sequence. Provide operator training and awareness.

2 SUMMARY OF WORK DONE

In late-July and Early-August 1988, pilot experiments were done on the Astotin Lake site using the mobile pilot facilities of the AEC. Several trials involved operation of the Administration Site water plant, and the existing plant in combination with field pilot facilities.

Between April 1988 and August 1989, water was sampled periodically and tested at AEC for basic chemical parameters. Several of these samples were used in an evaluation of ozonation as a possible treatment process.

In June 1989, much of this information was incorporated into an interim report[5].

By September 1989, a preliminary evaluation of the problems with the Administration Site plant had been made. Schedules were established to optimize the existing plant operation, and operator training. Also, work with carbon test filters would be undertaken. Much of this planning is included in Appendix 10.5, in the internal papers tilted "Elk Island Experimental Proposal" and "Elk Island Work Program (Fall 1989)".

In November, 1989, Water Engineering Research Branch Engineer, Brian Gray, and Technologist, Hugh Mack, worked on plant optimization and trained Elk Island operators on the proper operation of the plant.

After the two-week operator training session was completed, H. Mack made frequent visits to support the operators and provide additional training as needed. This close support was provided until the end of the year.

In January and February 1990, H. Mack continued his weekly visits but gradually reduced his direct involvement and review role, reverting to a resource role. This evolution was completed by March, when the frequency of visits was reduced and the primary purpose of the visits became sampling.

Sampling of raw and treated water by the AEC was stopped in August 1990.

During the year of close plant monitoring, and the previous year of raw water observation, experiments on ozonation of Astotin Lake water were run on a regular basis. This work tested year-round effectiveness of ozone, and provided more information on the treatability of Astotin Lake water.

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[5]Appendix 10.3.

During the summers of 1990 and 1991, a series of test carbon filters were observed at the Astotin Lake site to define better the role that carbon may play in the future.

3 PALATABILITY DETERMINATION

3.1 Introduction

Elk Island staff were asked to complete two water use and quality surveys prepared and distributed by AEC technologists. Copies of these surveys, which took place in July 1988 and August 1990, are included in Appendix 10.6.1 and 10.6.2, respectively. Response to both surveys was good, with about 22 respondents each. Unfortunately, only four people responded to both surveys making comparisons more difficult.

Complementing the information from the surveys is data obtained from a series of four odour panels, carried out in late-July and early-August 1988.

Addition background information, and clarification of opinions, was gathered through informal discussions held with several members of the Elk Island staff over the period of AEC involvement.

3.1.1 July 1988 Survey

The first survey was conducted in July 1988. Circulation and collection of the survey was completed before any work had been done on the plant, or any upgrading of the operator training had started.

The questionnaire was designed to assess consumer concerns and their perception of the degree of variation in water quality being experienced. Information from the survey was also intended to provide information on the usage patterns and quality requirements for this plant. Since no expectations for final results had been made, no "before/after" pattern questions were included in this questionnaire.

3.1.2 August 1990 Survey

The second survey was taken in August 1990. Several physical changes (mostly minor alterations or additions) had been made to the plant since the last survey. Operations had gone through three distinct phases:

(i) Increased operator attention with minimal outside help;

(ii) A completed operator training period followed by a high degree of operational direction by AEC staff; and

(iii) Return to full operator control of the plant.

The design of the questionnaire was different from the first to reflect the changes made to the system. Relevant questions from the first survey were incorporated into the second questionnaire to provide continuity. Some questions that appeared to cause confusion in the earlier questionnaire, or were not found useful, were altered or deleted. Several sections were added in an attempt to provide a numerical rating of consumer satisfaction. A comments section was also included in the second survey.

3.1.3 Odour Panels (Palatability Panels)

Park staff participated in four odour panels held on July 21, July 25, August 5 and August 10, 1988. Some volunteers participated in several panels, but a standard panel was not set up and no training was given beyond simple instructions[6].

In each test, panellists were given between six and eight unidentified samples. Panellists were asked to rate each sample as aesthetically acceptable, or unacceptable, and to describe any detectable odours.

Although the written instructions were clear (see Appendix 10.6.3), and the panel director verbally advised against giving additional comments, several members of the staff provided additional useful information by taste testing the samples.

The sample sets consisted of water produced from the existing plant under AEC operation (except for one sample of park water being distributed at the time of the test) and control samples of Edmonton tap water and laboratory-grade water processed with reverse osmosis and de-ionization (RODI).

Most samples were taken with the plant under altered operating conditions and/or with additional pilot treatments, in various combinations, included in the process stream.

Each sample was presented in its raw form, and with a carefully controlled dose of chlorine added to simulate the final chlorination step in treatment. None of the water produced by the AEC was allowed to enter the park's distribution system during these experiments.

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[6]The set of instructions given has been included as Appendix 10.6.3.

3.1.4 How Results Were Assessed

Because the number of responses to each question was limited, a rigid, statistical analysis of the survey results was not attempted.

Survey results were used as a tool for assessing the plant performance over time. The responses also offered clues that helped to identify problems and focus attention on areas of concern. In this section of this report, survey results have primarily been used to gauge consumer expectations and attitude.

Odour panel results complement the survey results in the assessment of consumer preferences. They also provide clues as to the suitability of the treatment options used in those tests, and to the composition of odour-causing elements in this water[7].

Appendix 10.6 contains summaries of the surveys and panel results. Most of the responses from park staff are represented, including all survey responses. Blank samples of the questionnaires are also included for wording and context reference. Efforts have been made to provide some anonymity to those who signed replies. Special arrangements can be made to provide name-deleted copies of the originals, if required.

3.2 Discussion of Survey Results

3.2.1 Colour

One of the major problems that AEC was requested to investigate, and that was obvious in all the early samples of this water, was the brown colour present in the product water of 1988.

Much of the early effort was directed toward solving this treatment problem. Changes made in the operation of the plant have alleviated this problem, as confirmed by laboratory data noted later in this report.

From a review of the July 1988 survey data, it was noted that few references were made about the colour (only 3). There was no specific question about colour in the questionnaire but dissatisfied consumers usually find a way to include major concerns. Although the questionnaire did not address colour specifically, any major colour-related concerns would likely have been mentioned by participants.

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[7]See section 5.3.2 - Identification of Odours.

General response on colour was not expected in the odour panel tests as the test samples were presented in shallow, clear plastic cups that would not show colour well. Some of the tests were conducted in rooms with fluorescent lighting, further affecting colour perception. Even with these conditions, several comments on colour were recorded during the testing. This suggests that the panel members have concerns about colour. It is possible that colour complaints may have been secondary to other problems in the replies to the first survey.

Replies to the August 1990 survey contained no references to colour in the water.

3.2.2 Chlorine

Two concerns appear to be dominant in the survey replies. Chlorine is the easier of the two to address.

Early AEC observations of the Administration Site plant included notes about overwhelming amounts of chlorine in the water. Replies to the first survey contained ten direct references to high chlorine levels.

Odour panel responses had eight references to chlorine, with the two most strongly worded related to the sample of the Administration plant water that was being distributed in the summer of 1988.

Part of the problem was solved when the chlorine analysis kit in use was found to be giving readings much lower than actual and was replaced. System improvements made between surveys include better controlled chlorine addition, and reduction of the demand for chlorine in the water with more efficient treatment.

The 1990 survey replies had three references to chlorine. Two of them referred specifically to an episode in the winter.

Four of the chlorine-related comments, given by the odour panels, were from test waters where the chlorine was carefully controlled and measured, and were within a widely accepted range for drinking water. The fact that other tested samples had the same levels of chlorine, but drew no comments, could be due to masking of odours and/or could be related to the points raised in the next few paragraphs.

In late winter 1991, the primary operator of this system had noted that most of the comments or complaints that he has had received in the previous half year had been about chlorine. While some complaints were made at times of known upsets in the system, others were

made when normal levels of chlorine were measured, but when other changes were occurring in the system. One change noted was in pH.

The relationship between pH and chlorine smell in a chlorinated water is well known, and is the result of the balance of chlorine radicals in the water. Hypochlorous acid is the main species present below pH 7.5, and is the main odour-producing compound in chlorinated water. Hypochlorite is predominant in water above pH 7.5. It produces less odour and is a less effective disinfectant[ref.1].

Early guidelines for pH that the AEC had provided for the Administration plant operators were broad, allowing them to operate between pH 7 and 8. After the observation was made that the customers are sensitive to the odour of chlorine, the guidelines were tightened (with agreement from the primary operator). The target pH range is now 7.6 to 8.

While control of the pH-related chlorine odour is a simple way to reduce complaints, some evidence suggests that the complaints over chlorine may have deeper roots, as can be concluded from the aggregate of the following points:

(i) The second questionnaire included a request to rate the safety of Edmonton water on a scale of 0 to 5[8]. Four people (22%) felt Edmonton water was marginally safe or unsafe (score 0 to 3), with the remainder believing it was safe for consumption. Only four rated the water as completely safe (5).

(ii) In results from the August 5 odour panel, two respondents rated Edmonton water (not identified to them) as unacceptable due to high chlorine. Both of these respondents rated Edmonton water acceptable in other tests. This could indicate a genuine upset in the Edmonton operations (in this case affecting the use of the sample as a control), but the chlorine levels were unlikely to be out of Edmonton's guideline range.

(iii) In separate discussions with park residents, several people indicated to AEC staff that there was distrust about the safety of adding any type of chemical to water.

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[8]The wording of this question was slightly different than questions asked about Elk Island water. For this reason, the response can only be applied crudely as a base line for the results of the Elk Island questions.

Some of the uneasiness felt by the four who rated Edmonton water poorly in the August survey, and to a certain extent the two negative responses in the Aug. 5 panel, may reflect similar sentiments as those raised in the discussions in case (iii).

Chlorine is the most obvious water treatment chemical to a consumer. With some of the customers of this water system concerned about chemicals in their water supply, chlorine odours may trigger negative responses at levels that would be considered normal in other systems.

Even in light of the preferences for low chlorine levels shown in these surveys, the safety of this water for consumption must take precedence over aesthetic concerns. While levels should be carefully controlled, an appropriate chlorine residual has to be maintained throughout this system.

3.2.3 Organic Odour

The second common concern voiced in these surveys was what was described as "swampy" or "sloughy" tastes.

In the first survey, twelve people used the "swampy/sloughy" terms to describe the Administration plant product water. In addition to the twelve direct references to these tastes and odours, two people called the water "stale" or "stagnant" and three used descriptions such as "terrible" (possibly a combination of chlorine and swampy tastes). Between 14 and 17 comments can be said to be common or related in type.

The August 1990 survey had one less reply than the first survey. The replies contained three "swampy/sloughy" comments, two "musty/moldy" descriptions and two people described the Administration plant product as being like "chlorinated lake water". One person said the water had an organic taste, making a total of eight related comments.

While the second survey demonstrates a reduction in the number of descriptions of this type and in the severity of descriptors used, it is clear that a concern still existed.

Very few of the treatment combinations used in our experiments completely removed organic-related odours (as detected by the odour panels). While few or no panellists had noticed problems in certain waters, they recorded the presence of organic odour after chlorination (a widespread problem partly covered in the Section 5.3). Water from the Elk Island plant operated under near-optimum conditions was one of the cases where odour was detectable only after chlorination.

3.2.4 Water Quality Trends

Parts of the two questionnaires were intended to indicate trends in the treated water quality. These questions were designed to determine the times of the year that extra diligence might be needed to treat predictable source water changes (such as lake turnover, algae blooms or runoff).

The first survey responses contained relatively few indications that summer might have the worst problems, and 19 other descriptions indicated that the water quality changed as often as daily. This left the impression that many of the reported changes were related to chlorine.

There were relatively few answers to similar questions asked in the 1990 survey. Those who answered indicated that there have been upsets in quality, and that there is a likelihood that treatment problems are caused by the water characteristics during spring and summer.

Our own observations indicate that in early August the treatability of the water deteriorates and that the results from the odour panel experiments are likely to represent some of the worst taste and odour conditions of the year.

3.2.5 Consumer Confidence

Information from these surveys indicates a lack of consumer confidence in the earlier water and the water being produced in the summer of 1990.

There was no significant change in the number of people who indicated that they use additional treatment (primarily the use of an in-office distilling unit) between 1988 and 1990. There was a reduction of the number of people who hauled water into the park for drinking (although 6 of 21 indicated that they still did so).

The most obvious indication of lack of confidence is that average rating for drinking of 1.3 out of 5, which was given this water by the respondents to the August 1990 survey.

4 PHYSICAL PLANT INSPECTION AND ASSESSMENT

4.1 Recommendations From Interim Report

In the interim report[9], Brian Gray recommended the following changes to the Administration Site water plant:

(i) Addition of flow meters with totalizers at both the plant inlet and on the distribution system feed line.

(ii) Addition of a sample point after the chlorine injection (but before the line empties into the reservoir).

(iii) Modifications to the sludge sample points for clearer determination of the clarifier status.

(iv) Replacement of the chemical feed system with the suggested set-up.

(v) Addition of chemical feed ports and a rapid mix chamber to the clarifier.

(vi) Modification to the backwash system to increase the backwash flow.

(vii) Addition of a sample control system to operate a carbon test filter.

Several modifications were implemented soon after the interim report recommendations were submitted. The early installation of the flow meters, post-chlorine sample point, chemical feed system and rapid mix vastly improved the operating characteristics of the plant.

A simple sample control system was installed with minimal delay after the appropriate location was defined and parts were provided by the AEC staff.

There was a significant delay in the installation of the backwash system. This system is currently in operation and performs suitably when adequate attention is given to the backwash process by the operators.

No changes to the clarifier sampling system have been made at the time of this report.

4.2 Recommendations Identified After Interim Report

During the period that AEC technologists were working directly with the plant and training the operators, the need for additional modifications was identified.

Depending on the scope of the changes, suggestions for alterations were communicated to the operators, site manager or the Capital Works coordinator. As a result of these suggestions,

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[9]Appendix 10.3.

several improvements were made to the Administration plant. Included in these improvements were a cleanup of the plant (undertaken by the lead operator in an impressive manner) and the removal of solids that had accumulated for years inside the clarifier.

The filter level controller was found to be operating improperly. Park staff had the controller repaired and installed air line pre-filters, as recommended.

• Important additions to the plant included a new liquid chlorine system and chemical test equipment. The liquid chlorine system replaced the old gas system, which was found to be oversized and difficult to control. The liquid system is far safer to operate, eliminating the lethal hazard of gaseous chlorine.

Figure 1 plots free chlorine concentrations, measured by the plant operators, at the trades shop sink (the farthest point in the distribution system). Better operator control of chlorine levels gained by using the new injection system can be seen.

New chemical test equipment was needed since the old kits were limited in scope and were found to be giving inaccurate results. The system purc-cd[10] is simple to operate, accurate and versatile. The new test kit is capable of monitoring an extremely large range of parameters with operating costs similar to the kits being replaced. Much of the operation data contained in this report was measured by operators using the Hach spectrophotometer.

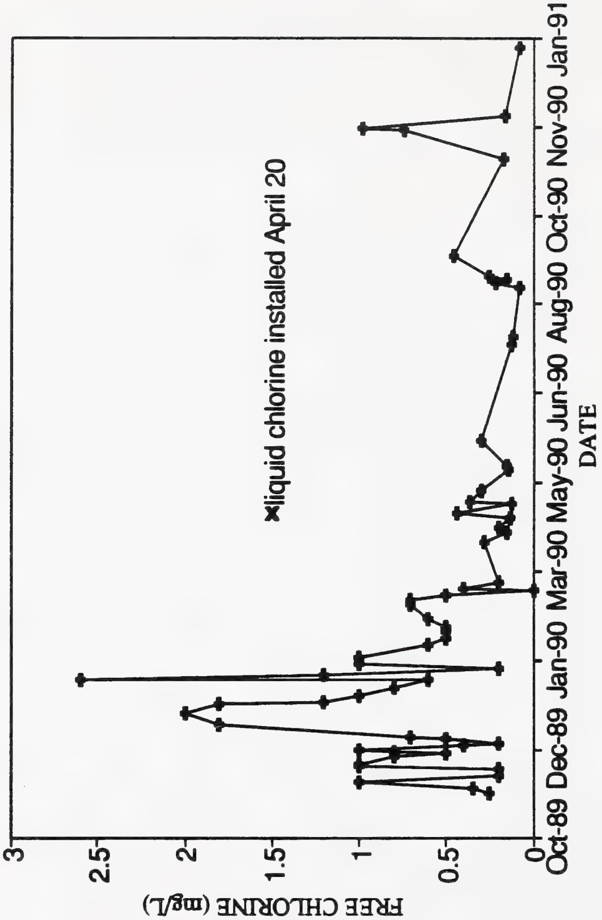
4.3 Additional Equipment Requirements

A polymer feed pump was identified as an additional requirement for plant operation during the "hands on period". No pump has been purchased to this point and the AEC has recently removed a pump that was loaned to the park for two years.

Installation of sample points in the clarifier is still needed. Without sample points, the operator cannot observe the conditions to the floc bed. This affects his ability to control the process and increases the likelihood that upset conditions will occur.

[10] A. Hach DR2000 spectrophotometer.

FIGURE 1. - FREE CHLORINE RESIDUAL
AT FARTHEST USER - CONTROL POINT



During the initial cleanup of the clarifier, it was found that the flow of water was impaired by plugging of four, 3/4 inch orifices in the internal cone. This caused additional back pressure and altered the flow patterns inside the clarifier from the designed pattern.

After B. Gray manually unplugged the holes, operation of the clarifier improved.

In was found that after only weeks of operation the problem conditions returned. The problem was traced to an inner channel in the cone that is prone to plugging.

Operators have found it necessary to unplug the cones manually on a regular basis. During the busier periods, this job is put off, adversely affecting operations.

The internal cone should either be modified to reduce the incidence of plugging, or the internal structure of the clarifier should be modified to an alternative design.

4.4 Maintenance Requirements

Most of the taste and odour control measures covered in this report are based on addition or modification of equipment or operation inside the water plant.

Taste and odour control at the Administration Site plant can also be enhanced by proper maintenance of the distribution system.

Some improvement in water quality in the distribution system was achieved after the lead operator discovered that one half the product water reservoir was partially isolated from the main flow stream by a baffle. He altered the plumbing of reservoir feed to allow both chambers to mix during operation.

Improvements in the operation of the water plant would be expected to cause a gradual clean-up of the distribution system as polished water flowed through it. Decreased system-related contamination was evident from a reduction in the chlorine demand of the system over time (see Section 6.3.3).

The treated water reservoir received poor quality water for more than a decade. It can be expected that a layer of filth, similar to that found inside the clarifier, resides on the bottom of this tank. Such a layer could contribute to taste and odour in the system.

Draining the reservoir for cleaning would present an opportunity to inspect and assess the condition of the concrete. Given the proximity of the plant to the lake and the reservoir location below water level, cracks or other defects in the wall of the tank may allow ground water infiltration into the system. Groundwater could interfere with the ability of the system to hold

a chlorine residual. It could also contribute contaminants that have the potential to reduce the quality of the distributed water.

In addition to cleaning the reservoir, the distribution system should be completely flushed. This is normally done in systems by increasing the pressure and opening hydrants at end points in the system. The Elk Island system does not have the hydrants or sufficient pressure to properly perform this job. Therefore, greater effort and external pumps are needed. Note that if a flushing operation were undertaken, only treated water should be used for this purpose.

Two other concerns with the distribution system occur in the residences served by this plant. The first is regular maintenance of hot water heaters. In general, many people realize that regular blow down of water heaters should be done, but few actually do it. In the park situation, blow down of the heaters should remove buildup of material inside the heater that could potentially decompose and produce odours.

The second concern about the residences stems from the past installation of carbon cartridges. Some effort was made during this study to investigate the benefits that carbon might provide to this system. However, there are several problems with the type of installation in these residences.

Replacement of the cartridges in individual residences is left to the occupants. It is probable that some occupants don't know they should be doing this. In some cases, replacement only occurs when the filter plugs and prevents water from flowing into the house.

Activated carbon contains a multitude of tiny passages and holes. Organic material can be physically trapped or adsorbed onto the carbon, which is why it is used in water treatment. This protected environment, with an organic food source, also provides an ideal growth medium for bacteria. Excessive growth of bacteria on these cartridges may be a health concern, depending on the types of organisms involved.

The location of the cartridges is also a concern since carbon also can remove chlorine from the water. If chlorine is removed at the entrance to the house, as in the case of these filters, the piping in the house has no disinfectant ability and problem growth can occur within the plumbing in the building.

The American Water and Wastewater Association has concluded that home water treatment devices are unnecessary when a controlled public water supply is available. They also claim that they can cause degradation in the quality of the water if maintained improperly[11].

Removal of the cartridges installed in Elk Island residences should be considered.

[11]Position stated in Appendix 10.9.

5 WATER QUALITY

5.1 Raw Water

A full chemical analysis was performed on an Astotin Lake water sample[12].

Table 1. Summary of Selected Analysis March 1988 Sample of Astotin Lake Water.

PARAMETER	CONC. (MG/L)	PARAMETER	CONC. (MG/L)
Iron	<0.02	Manganese	0.030
Calcium	35	Hardness	206
$NO_2 + NO_3$	<0.02	Phenols	0.010
Fluoride	0.20	Total Dissolved	
Sulfate	10	Solids	274
Alkalinity	255	Bicarbonate	311
Ammonia	0.044	Tannin & Lignin	0.50

Parameters from this set of analysis that were included in Table 1 were below detection limits or were at trace levels.

A March 24/1988 analysis[13] showed iron at a minimal level of 0.03 mg/L but manganese at a moderate 0.10 mg/L[14].

From these analyses, Astotin Lake appears to have good quality water by inorganic chemical standards. The water is hard (average for the prairies) and has a fairly high alkalinity, neither of which poses a health hazard.

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[12]Analysis done by Alberta Environmental Centre, Chemistry Division, March 1988.

[13]Analysis done by Alberta Environmental Centre Process Control Lab.

[14]Twice the proposed maximum limit for aesthetic purposes - Canadian Drinking Water Guidelines[ref.2].

Manganese appear to fluctuate around levels where problems with staining in households might occur. Survey responses do not indicate that the characteristic, manganese-related, black stain is occurring. Operators should be aware of the potential for staining to aid in troubleshooting future problems. Manganese removal processes are discussed in Section 7.3.5.

The higher levels of manganese present during some of the ozonation trials caused the water in the ozone contactors to turn pink, indicating the formation of potassium permanganate. This reaction is not alarming, but did catch the attention of the technologists as a note of interest.

Tannin and lignin are a series of compounds that leach from decomposing vegetable matter and contribute to colour in water. They are not considered a health concern. Levels of these compounds in Astotin Lake water are about two to five times the level where colour can be detected by the human eye. These dissolved compounds likely contribute to the colour of this water as do other compounds, such as humic acid, which were not included in this analysis. For the purpose of this report, laboratory colour analysis was used as the primary tool in assessing related problems.

The phenols level is notable since many phenolic compounds can produce strong odours. The characteristics of phenol-related odours are covered later in this section. The phenols level of 0.010 mg/L detected in this sample of Astotin Lake water is five times higher than the 1978 aesthetic objective for drinking water[ref.3] (no limit has been included in the 1989 standards).

5.2 Monitored Parameters

5.2.1 Colour

The colour determination methods used by the Alberta Environmental Centre are as outlined in the Interim Report[15]. In addition to these methods are apparent colour measurements provided by the operators of the Elk Island water plant, that were made using a Hach DR2000 spectrophotometer. While the Interim Report refers to colour measured on a filtered and pH adjusted sample as "actual colour", this report will use the Standard Methods[ref.4] term "true colour".

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[15] Included in Appendices, section 10.3.

Figure 2 shows that apparent colour in the raw water supply (Astotin Lake) was lowest during middle to late winter, 1989 - 1990, at about 50 CU. It rose in spring, 1990, maintaining levels between 60 and 80 CU for the rest of the study year.

Figure 2 also shows that true colour varies little during the year (between 15 and 20 CU). This suggests that the bulk of the Astotin Lake colour problem is caused by filterable material[16]. To clarify the colour terminology further, the colour indicated by true comprises extremely fine particulates and dissolved chemicals. Apparent colour includes what was measured as true colour, and also reads much of the larger particulate material.

Health and Welfare Canada sets an aesthetic objective of ≤15TCU[ref.2]. This indicates that any Elk Island plant has to use physical means to remove the bulk of the colour-causing filterable material, and then chemically treat the remaining colour to reduce it another 5 to 10 CU, to fully meet the objective (Technically, apparent colour is not included in the objectives.)

Figure 3 shows that the Administrative Site plant effectively removed true colour for the year that lab measurements were taken on a weekly basis. Figures 3 and 4 indicate that the plant operation was less consistent in removing apparent colour during the same period, and through to early 1991. Even though there was variability in the product water quality, the median value of all the readings taken through the year is below 25 CU.

5.2.2 Turbidity

Turbidity is an important measurement of plant performance. It is an index of the cloudiness of water caused by particles. High turbidity in a product water is an indication of problems with plant filters or other upsets. Excessive particulates in the water can shield water-borne microorganisms from disinfection, creating a health concern.

The recommended maximum turbidity for treated waters is 1 NTU[ref.2]. Short-term production of water over 1 NTU (up to 5 NTU) is not a serious problem. Repeated or long-term production of high turbidity water is a health concern.

Operator-collected turbidity information on the raw water supply is included as Figure 5 (Units used in Figure 5 are FTU; a comparison of turbidity units is contained in Section 6.3.2).

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[16]Material than can be removed with a 0.8 micron filter.

FIG. 2. - ASTOTIN LAKE WATER QUALITY
COLOUR - LAB DETERMINED VALUES

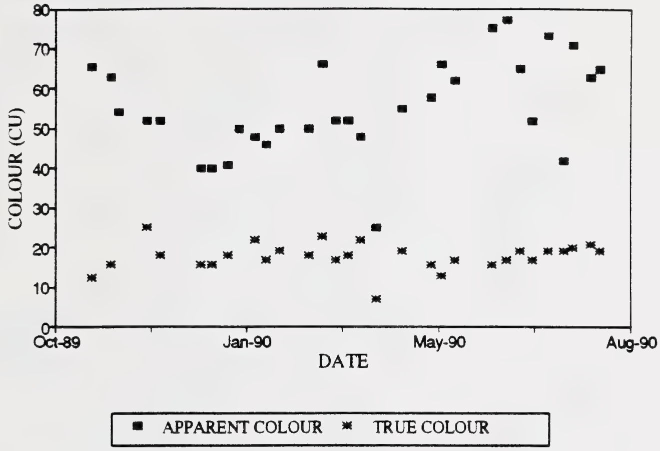


FIG.3. - TREATED WATER QUALITY
COLOUR - LAB DETERMINED VALUES

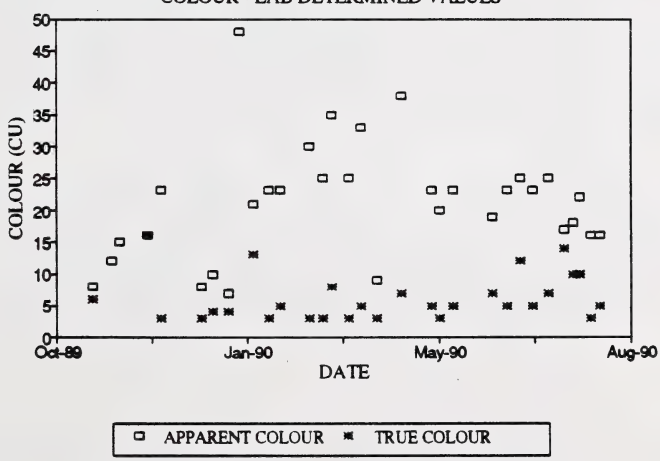


FIG.4. - TREATED WATER QUALITY
APPARENT COLOUR - DR2000 AND LAB VALUES

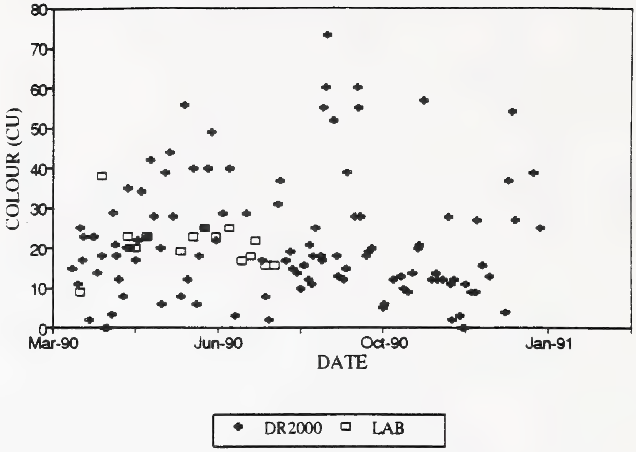
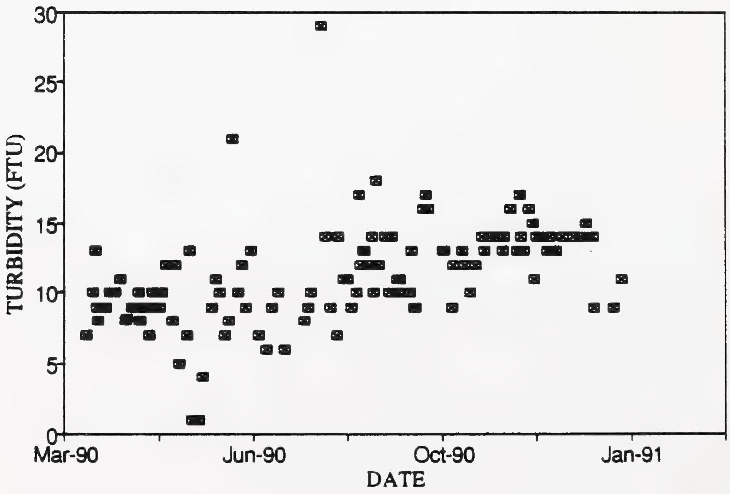


FIG.5. - ASTOTIN LAKE WATER QUALITY
TURBIDITY



5.2.3 Conductivity and pH

Conductivity measures the ability of a solution to carry electrical current. This ability is related to the concentration of ions in solution and the temperature of the solution (among other factors affecting the ions). Solutions of inorganic acids, bases and salts are good conductors and organic compounds are poor conductors.

The conductivity of Astotin Lake water varied, between 200 and 400 uS/cm, during the year of monitoring. This is a relative low number which correlates to the mineral content of this water (Section 5.1).

Conductivity of the water after treatment by the existing plant was measured at 400 to 700 uS/cm. Higher conductivity in the product water is not alarming as it reflects the addition of chemicals during the treatment process. The changes in treated water conductivity appear to follow the changes in the raw water value and the addition of conductivity by treatment appears to be reasonably constant (see Figure 6).

The raw water pH appears to change in a yearly cycle. From values near pH 9 recorded in the fall of 1989, it dropped to pH 9 or below in the spring of 1990, then slowly climbed again. There did not appear to be a very large day-to-day change during the recording period.

Drinking water pH between 7 and 8 (6.5 to 8.5 in the drinking water guidelines[ref.2]) is generally accepted, primarily based on the corrosiveness or deposit-forming characteristics of water outside this range.

Treating the water with alum (aluminum sulfate), as done with this plant, lowers the pH well below 7. To bring the pH back into the accepted range, soda ash (sodium carbonate) is added.

Figure 7 demonstrates the ability of the Elk Island operators to control the pH in the target range (pH 7 to 8). After discussions between Elk Island staff and AEC technologists in January 1991, the objectives for pH control were tightened to pH 7.6 to 8 to help reduce chlorine-related odour (Section 3.2.2).

5.2.4 Odour and U.V. Absorption

The City of Edmonton experiences taste and odour problems during the spring run-off period. One approach taken in work with these problems was an evaluation of various analytical tools in an attempt to monitor the problem in the plant feed and treated waters.

FIG.6. - WATER QUALITY, RAW & TREATED
CONDUCTIVITY

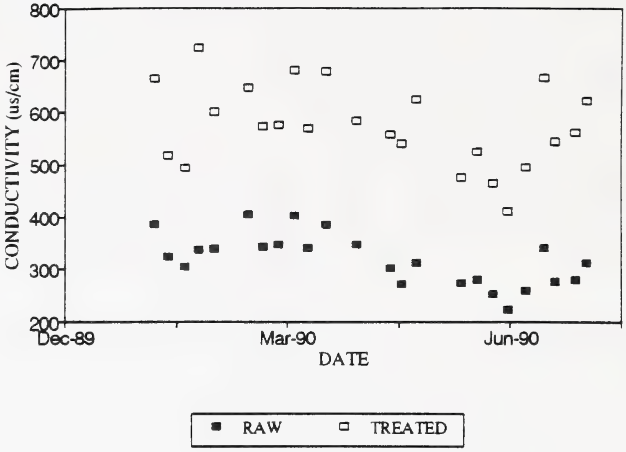
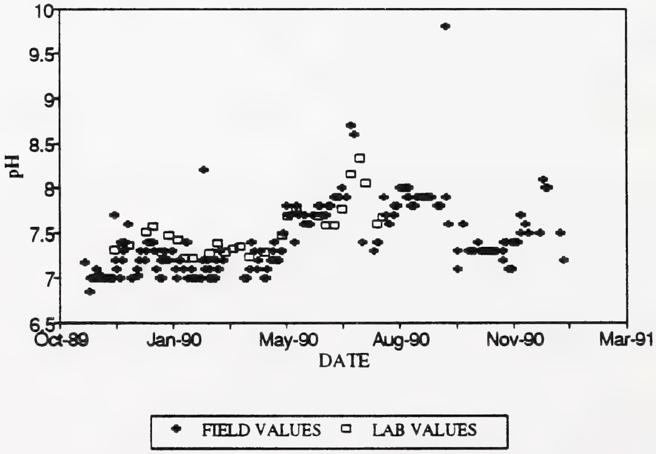


FIG.7. - TREATED WATER QUALITY
pH - FIELD AND LAB DETERMINED VALUES



City of Edmonton chemists and engineers have determined that several compounds that contribute to the Edmonton odour problem originate from decomposing vegetable matter washing into the river[ref.5].

Concentrating on humic substances, the measurement of colour with ultraviolet light was explored for use as an indication of the presence of compounds associated with odour[ref.6].

During this program, city staff drew water samples at the residences of people who called in odour complaints. Ultraviolet (UV) absorbance was measured on these samples at several wavelengths. It was determined that when treated water UV colour reached 10 humic acid units (about 1.3 absorbance units at 200 nm wavelength) odour complaints could be expected.

Figure 8 is a record of UV absorbance of Elk Island raw and treated waters taken over a one-year period. The solid line across the graph represents the level of UV absorbance associated with odour complaints in Edmonton. While raw water results exceed this level for half the year, no sample of treated water approached this limit.

Several odour complaints had been filed in Elk Island during the year covered in Figure 8. Operator tests (warming water in a closed container, lifting the lid and noting odour) also detected some degree of odour throughout the year.

From this information, it appears that the odour - UV absorbance relationship reported in Edmonton does not take on the same characteristics in the Astotin Lake case.

Regarding trends in UV absorbance in water from the Administration Site plant, Figure 8 indicates that the lowest recorded values occur in the fall. A second, less notable, low level appears to occur in the late spring. All other readings were recorded at between 1 and 1.2 absorbance units.

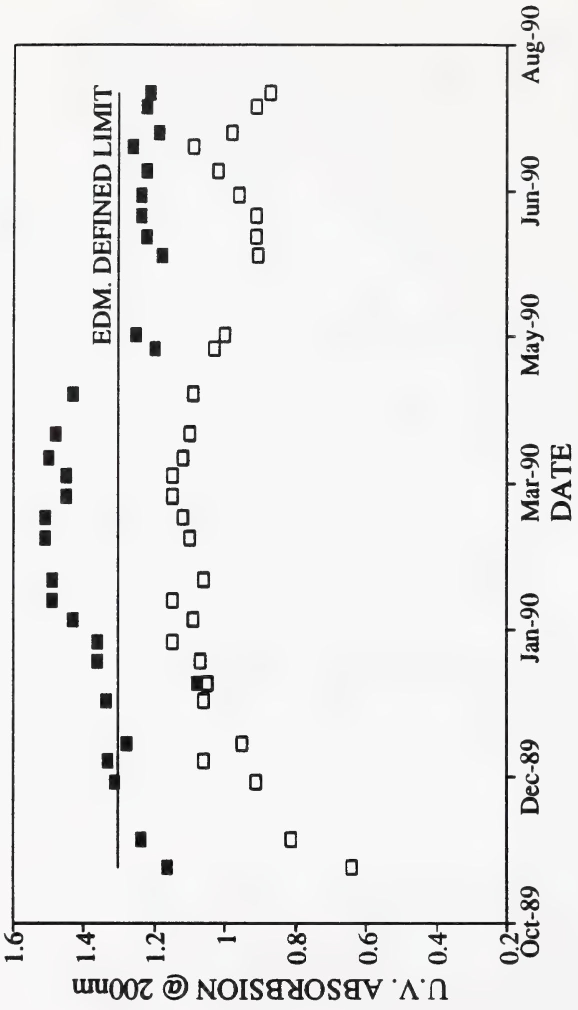
If a relationship between UV and the odours in water is real, detectable odour in Astotin Lake water is present below the UV levels observed in Edmonton. Data collected would then indicate that the only break in odour in this water would occur in the fall.

5.3 Taste and Odour

5.3.1 Chlorine

Survey results (Section 3.2.2) demonstrated the importance of chlorine of taste and odour in the Elk Island experience.

FIG.8. - WATER QUALITY, RAW & TREATED
U.V. @ 200nm



The chlorine/pH relationship, briefly covered there, is further defined by the following sensory threshold values[ref.7]:

Table 2. Sensory Threshold Values - Chlorine.		
(mg/L as Cl2)		
Compound	Odour Threshold	Flavour Threshold
Hypochlorous acid	0.28	0.24
Hypochlorite ion	0.36	0.30
Monochloramine	0.65	0.48
Dichloramine	0.15	0.13

As covered earlier, the degree of odour produced by chlorine in a water can be reduced by increasing the pH to a range where hypochlorite is the predominant ion.

The other ions, in the above table, are products of chlorine combining with ammonia. The City of Edmonton uses ammonia addition in its distribution system to outlying areas. Among the advantages gained is reduced odour. The ammonia content of the Astotin Lake water is such that chloramines are formed in concentrations of approximately one milligram per litre (total chlorine measured minus free chlorine measured). Chloramines are less effective as disinfectants than free chlorine. Since the retention time in the Administration Site plant can be relatively short, the AEC recommends that free chlorine residual be continued as the primary disinfectant in this system.

Other by-products of chlorination can produce odours that are stronger than those of either chlorine or the contributing compounds before chlorination. One series of compounds that have this characteristic are phenols.

In the following table[ref.8], a comparison between the threshold odour values of phenols and two of the more volatile chlorinated phenolic compounds has been made.

Table 3. Comparison Between the Detection Odour Threshold Values of Chlorinated and Non-Chlorinated Molecules.	
(mg/L)	
Compound	Threshold Value
Phenol	1.0 - 5.9
4-Chlorophenol	0.0005 - 1.2
2,4-Dichlorophenol	0.02 - 0.21

This table demonstrates the potential of one set of compounds, phenols, to produce odour in Elk Island water. It also helps to illustrate how a treated water that appears to have no objectionable odour can develop problems after chlorination. This effect was likely noticed during the odour panels and was noted as "odour return". In those panels, negative reaction to some of the chlorinated waters was indicated even when more positive comments had been made about the same waters before chlorination.

In contrast to many of the problems caused by chlorination, chlorine can be used to reduce taste and odour in water through a process called breakpoint chlorination. A description of breakpoint chlorination has been included in Section 7.3.4 of this report.

5.3.2 Identification of Odours

The tastes and odours identified by the Elk Island staff for the waters (from Surveys, Section 3) are listed below:

Table 4. Summary of Taste & Odour Descriptors from Survey Results.				
†swampy	†stale	†musty	†chlorine	†sloughy
†stagnant	†moldy	†chemical	†chemical	†acrid
skunky	metallic	soda	sour	sulfur
sour gas				

The first 10 of these descriptors (marked with a †) were used in descriptions of treated Elk Island water, although most referred to water produced under upset conditions.

Attempts have been made to classify tastes and odours in water by grouping them into categories based on the similarity of the odours and the frequency of occurrence. In a system being developed by the AWWA[ref.9] these ten descriptors (if used by a trained odour panel) would fall into three groups: Chlorine has a category of its own (Group 2); Musty/moldy descriptors represent the most commonly observed group (Group 1); Swampy/sloughy and stale/stagnant odours are in Group 4.

Group 1 odours can have a variety of origins. Due to the isolated nature of this lake, no discussion of pesticide, petrochemical or other chemical contamination is included here. Potential origins of this type of odour include by-products of algae growth and decomposition. Musty odours have been linked to moderate quantities of blue-green algae.

Some of the chemicals that cause Group 1 odours can react to chlorine in similar ways as phenol, meaning that they can be detected at lower concentrations than before chlorination. Some of these odours also can be masked by high levels of chlorine and may be detected only after the free chlorine starts to dissipate, or the water has been warmed. The observation of these odours in the second survey, but not in the first, may indicate masking by the stronger chlorine and heavy Group 4 odours present at the time of the first survey.

The Group 4 odours described for Elk Island water are frequently linked to decaying vegetation and generally have a sulfur-related component. Other descriptors that fall into Group 4 have not been described in Elk Island water (descriptors that include barnyard, fishy, rotten, garlic, manure, peat, pigpen, sulfur and sewage are often linked to yellow-green or golden-brown algae).

Phenolic compounds are grouped into Group 7. The descriptors normally include medicinal, sweet, camphor, phenol and alcohol. None of these descriptors appeared in replies. The level of phenol measured, in Astotin Lake water samples should not be high enough to be detected, but has the potential for odour when combined with chlorine. Since a trained panel was not used, it is possible that the people involved in the surveys and panels simply described any phenol-related odour as chlorine.

5.4 Trihalomethanes

Trihalomethanes (THMs) are a group of volatile organic compounds that are formed when water containing certain organic materials is chlorinated. Several compounds in this group have been identified as suspected carcinogens.

In samples drawn in July 1990, product waters from the Administration Site plant and the water system at the campground were found to contain trihalomethanes (primarily chloroform) at levels approaching 300 ppb. The current Canadian drinking water standard for THM is 350 ppb[ref.2].

Some concern about the Elk Island THM levels approaching the maximum recommended limits is justified, particularly in view of information that the standards committees are currently considering dropping this limit to levels as low as 50 ppb.

Experience with THM compounds indicates that it is usually more difficult to remove the chlorinated compound from water than it is to control precursors. In the case of carbon adsorption, removal of THM with carbon may be ineffective or impaired by competition with, and reduction of the adsorbing surface by, chlorine[ref.10]. Attempts to reduce THM formation potential with carbon adsorption have produced results that vary from poor to very good, with the results depending on the individual water supply[ref.10].

The coagulation process (at process taking place in the Administration Site plant clarifier) generally provides the best opportunity to remove organic materials related to THM formation[ref. 10]. The treatment process at the Administration site plant appears to be unable to remove THM precursors effectively when it is under upset conditions, such as those present during the July 1990 sampling. Additional treatment for THM removal may be necessary if the plant should have inadequate THM precursor removal under optimum operating conditions.

Additional treatment for THM is not directly covered in this report, but most of the methods for treatment covered in Section 7.3 have potential to reduce THM formation.

6 OPERATION

6.1 Historical Operational Mode

A complete history of operations at the Administration Site water treatment plant could not be constructed because all records were not available. No operator manuals, and little equipment or structural information is available. It is known that the plant was built in 1963 and that no major modifications had been made before this study was begun. Information provided by Rae Howe (Appendix 10.1.1) also indicates the colour, taste and odour were problems in the plant's early history. An investigation in 1966 of treatment options tested the effectiveness of adding activated silica (coagulant aid), potassium permanganate (oxidant) and powdered activated carbon (adsorbent). None of the options tried in 1966 were effective and their use was discontinued.

At the time that initial contacts were being made regarding this project, operators at the Administration Site plant were following procedures that were passed on by their predecessors. The operators had little understanding about the processes involved, and were generally misinformed. Production of water at the plant had a low priority assigned to it and there was virtually no quality control over the product water.

Early AEC inspects of the plant identified long-term neglect of basic cleaning, and malfunction of several elements of the process as the result of fouling.

Process control was virtually non-existent. Control over coagulation chemical addition was deficient. Chemical preparation was done according to a formula written years ago on the back of a door. The chemical feed pumps were incorrectly sized and in disrepair as the result of control over chemical addition was not properly understood, and the choice of chemicals added was often dictated by the mechanical condition of the respective feed pumps.

Chlorine addition was hampered by an oversized feed system that was difficult to control because it tended to drift.

Operator record keeping consisted entirely of a notepad where chlorine residual levels were recorded. Measurements of chlorine were made infrequently, and were inaccurate because the chlorine kit in use was faulty.

6.2 Operator Training

Training of Elk Island water plant operators by AEC technologists was undertaken in three stages: 1) Intensive training; 2) Close support; 3) Resource role.

Initially, the two AEC technologists worked closely with the operators in a two-week training session. The intensive training period was followed up with three months of regular weekly visits to the plant. In these visits, operations were closely followed, additional training was provided, and assistance was given to the operators when operational problems were encountered.

Over the next two months, the level of review and close support was reduced until the AEC role evolved to a resource for the operators. In recent months, Elk Island operators have infrequently requested information or technical support. AEC staff are still available as a resource for the operators.

The following is a brief outline of some of the material covered during the training of Elk Island staff. Note included here are the mechanical shortcomings identified, or the repairs and maintenance undertaken by the AEC technologists. Also not reported is the detail contained in hours of discussions with the Elk Island operators on the fine points of operation and general information involving the field of water treatment.

Points covered in Operator Training

- Importance, use and future benefits of operators logs.
- Use of log sheet designed at AEC.
- Chemical dosage calculations.
- Mixing of chemicals.
- Proper backwash of filter (importance and technique).
- Best levels to maintain in filters.
- Explanation of pH.
- Use of pH meters.
- How to set up and use jar tests.
- Objectives of chlorination and established guideline levels.
- Measurement of chlorine.
- Importance of turbidity and guideline levels.

- Measurement of turbidity.
- Basic principles of flocculation and sedimentation.
- Operation and characteristics of a properly operated clarifier.
- Guidelines for operation of the clarifier.
- Use of polymer in managing the floc bed.
- How to use a warm water odour test as an operational tool.
- Importance of a clean plant.
- How to keep a record of complaints and comments and use the information to benefit operation.

6.3 Monitoring Equipment

Prior to AEC involvement, water quality monitoring capabilities available to the operators at Elk Island were minimal and inaccurate.

During this study period, the AEC used a variety of sophisticated monitoring equipment. In addition to the equipment used in the field, a wide range of analytical resources was available through AEC laboratories.

Some of the AEC equipment was left with the Elk Island operators for several months. Data collected with this equipment was useful to operations and was used in this report.

While the data collected is useful to the operators, it would have been unreasonable to recommend purchase of equivalent equipment to the types used in this study for operation of a water plant of this size. Several types of visual comparison style chemical determination kits are available on the market. While these kits are inexpensive and can be accurate, they can also fail to provide good results as the result of operator bias or poor light conditions. For this reason, a midrange solution was recommended.

The equipment purchased by the Park for the two water plants included a Hach DR2000 spectrophotometer and an inexpensive "pocket pH tester". The pH tester provides an accurate pH value in digital form. The DR2000 is capable of measuring over a hundred parameters (with purchase of appropriate chemicals). More important to this application, the DR2000 combines measurement of turbidity, apparent colour, free chlorine and total chlorine in one piece of equipment.

6.3.1 Colour

The improvement in capability that the new equipment has given the operators, compared to the visual observation-based kit used for the early field-recorded values, is partly demonstrated in Figure 9. Figure 10 shows that the DR2000 readings follow the lab-determined values for apparent colour reasonable closely.

Comparing the two styles of analysis in Figure 10, the weekly lab analysis values appear to fluctuate less than the field values through the summer months. DR2000 values stabilized in the late fall and winter of this period. This may indicate the Hach spectrophotometer is affected by a wider range of turbidity than the lab method. Turbidity in Astotin Lake water fluctuates more during the months of open water caused by the influence of wind and temperature changes.

In the cases of the Administration and Campground water plants at Elk Island park, colour has importance in addition to the aesthetic concerns addressed so far in this report. The additional concern arises from the effect of colour on turbidity measurement.

6.3.2 Turbidity

All laboratory turbidity measurement done by the AEC, and many of the field measurements done by both the AEC and Elk Island staff, were taken using turbidimeters measuring in NTU units[17].

NTU measurement, using Hach ratio technology, is not adversely affected by colour in the water. In other words, turbidity measurement remains essentially consistent whether there is little or considerable colour in the water.

The units used for turbidity measurement by the Hach DR2000 are FTU[18]. FTU and NTU have very similar scales (1NTU and 1FTU are essentially the same unit). However, because of the way this unit measures FTU, readings can be affected by colour.

Figure 11 is a plot of treated water turbidity, taken by Elk Island staff over a nine-month period, against the apparent colour measurement on the same sample.

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[17]Nephelometric turbidity unit. Turbidimeters used were Hach ratio turbidimeters, models 18900 and 18900xr.

[18]Formazin turbidity units.

FIG.9. - ASTOTIN LAKE WATER QUALITY
COLOUR - OPERATOR LOGGED VALUES

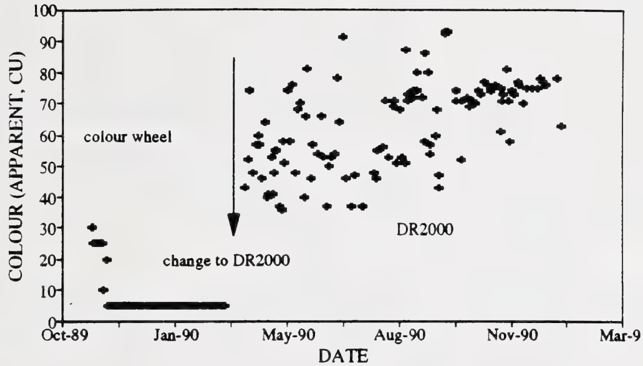


FIG.10. - ASTOTIN LAKE WATER QUALITY
APPARENT COLOUR - LAB vs LOG VALUES

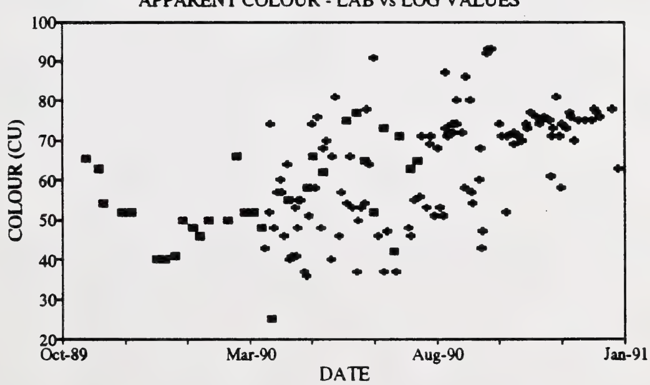
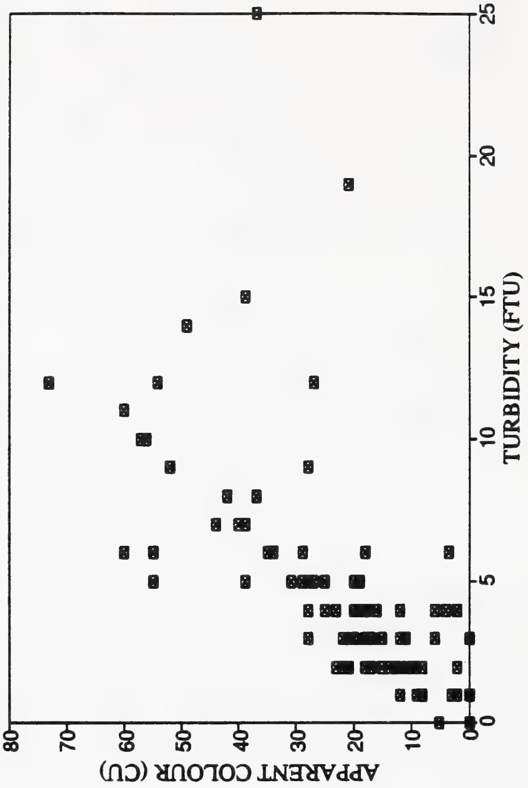


FIG.11. - TREATED WATER QUALITY
COLOUR INFLUENCE ON FTU TURBIDITY



In this plot, a trend toward higher turbidity measurements at higher colour levels is evident. Interpretation of this trend is not easy since there are at least three possible relationships: (1) Higher true colour affects the readings; (2) The apparent colour is in particulate form that can be read as both turbidity and colour; (3) As the Higher colour readings occur during upsets in plant operation, the turbidity has also climbed during the system upset.

Figure 12 plots lab-determined NTU turbidity against the true colour values from the same samples. The flat shape of the resulting curve is evidence that possibility (1) is not a major faction in Figure 11.

Figure 13 plots NTU turbidity and apparent colour in a similar manner as in Figures 11 and 12. This plot tends to support possibilities (2) and (3) by showing an upward trend of turbidity with apparent colour. It is probable that the upsets mentioned in possibility (3) are the major cause of the highest apparent colour and highest turbidity in samples drawn from the product water during this period.

Turbidity is an important measure for assessing water plant performance. The equipment available to the operators at Elk Island has the handicap of measuring FTU unit turbidity in a way that affected by the apparent colour. To confirm that this plant is meeting health guideline requirements of 1NTU, or to alert the operator to problems indicated by higher readings, colour in the product water has to be controlled.

Colour removal, in the Administration Site plant, primarily occurs in the clarifier. Most of the turbidity is also removed in the clarifier, but particulate finishing takes place in the filter. This means that an upset in the clarifier not only affects aesthetics (colour, taste and odour) and increases backwash frequency of the filter, but adversely affects turbidity measurement in the product water by allowing apparent colour to pass.

The purchase of additional equipment (turbidimeter) is expensive and should be unnecessary, if the operator recognizes the dangers associated with plant upsets.

Turbidity control has been a problem at the Administration Site plant throughout this study period (Figures 14 and 15). The plant is capable of producing low turbidity water, and does so during periods of smooth operation. Problems with the clarifier (Section 4.3) and periods of decreased operator attention are the primary causes of the poor turbidity performance.

FIG.12. - TREATED WATER QUALITY
TRUE COLOUR vs NTU TURBIDITY

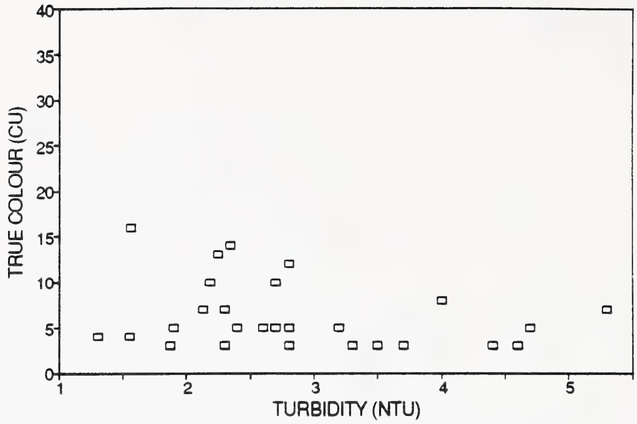


FIG.13. - TREATED WATER QUALITY
APPARENT COLOUR vs NTU TURBIDITY

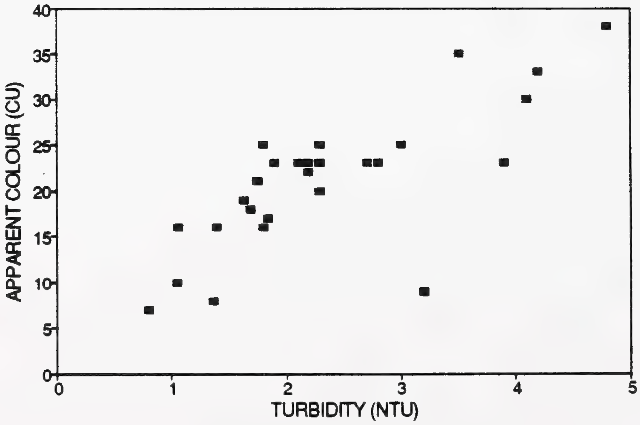


FIG.14. - TREATED WATER QUALITY
TURBIDITY - MONTHLY AVG., LOGGED VALUES

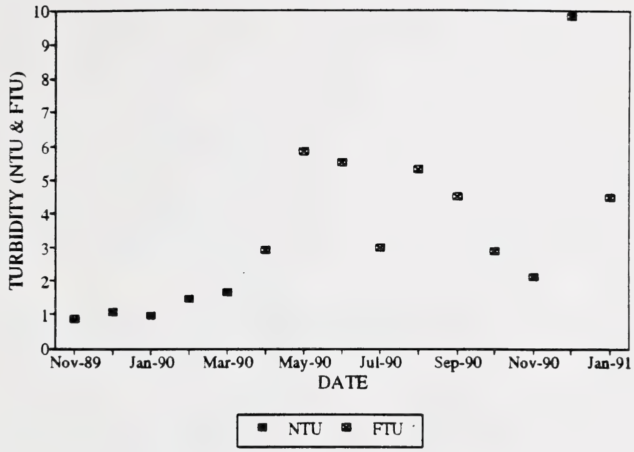
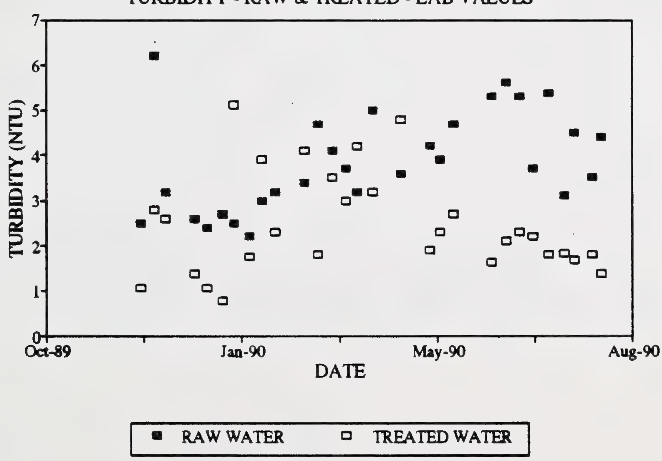


FIG.15. - TREATED WATER QUALITY
TURBIDITY - RAW & TREATED - LAB VALUES



6.3.3 Chlorine

In the period just after the new operating regimen was put in place at the Administration Site plant, chlorine had to be added at a dose of over 4 mg/L to produce a free chlorine residual of 2 mg/L in the product water reservoir. This high level in the reservoir was required to maintain a suitable residual of 0.2 to 1 mg/L free chlorine at the farthest user in the distribution system (Trades Shop). Efforts were made on Fridays to fill the reservoir with as much freshly chlorinated water as possible, so a detectable chlorine residual would be present on the following Monday.

The high rate of chlorine loss in the distribution system was related to the demand for chlorine[19] in the water and materials in and of the distribution system.

Chlorine demand in the distribution system started to drop soon after higher quality water production started. Figure 16 plots the free chlorine residual measured in the water plant (post-reservoir, start of distribution system) against the free chlorine at the end user (Trades Shop). Direct comparison of feed and end user residuals cannot be calculated based on a mass balance because of the time lag related to the volume of water in the distribution system, the changing rate of water usage, and problems with control of the chlorine system (until the addition of liquid chlorine feed).

Figure 17 plots the same data as Figure 16, but presents points as running averages with the calculation influenced by the frequency of sampling around each point.

From Figure 17, it can be seen that in November and December 1989, feed to the distribution system had a normal free chlorine residual of approximately 1.5 mg/L and the measured residuals at the Trades Shop averaged nearly 0.6 mg/L. By May, the chlorine loss in the system had decreased to a point where no separation in residuals was evident, suggesting that the system demand was minimal. Lower chlorine demand in the distribution system indicates that much of the offending material had been gradually consumed by chlorine or flushed from the system.

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[19]Chlorine demands is the consumption of chlorine by materials being oxidized by the chlorine.

FIG.16. - DISTRIBUTION SYSTEM CHLORINE
FREE CHLORINE - RESERVOIR vs END USER

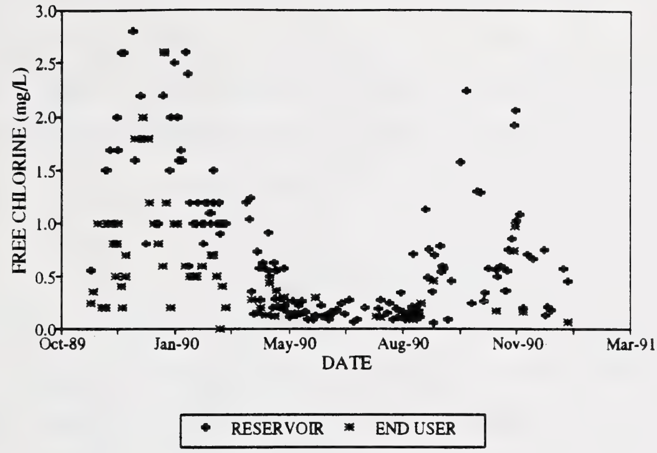
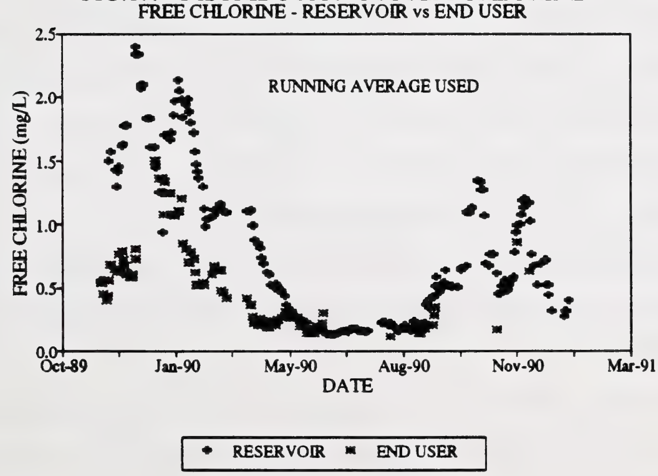


FIG.17. - DISTRIBUTION SYSTEM CHLORINE
FREE CHLORINE - RESERVOIR vs END USER



High free chlorine residuals recorded in the fall of 1990, seen in both figures, appear to be the result of lower chlorine demand in the product water. This is related to higher quality raw water.

Operators recorded few Trades Shop residuals in the fall and early winter of 1990. The high water plant residuals recorded at the time suggest that chlorine control was often neglected during this period of changing raw water conditions.

6.4 Documentation and Quality Control

Much of the information used to write this report was obtained from operator logs and notes. No credible notes were available from the period before AEC involvement, so almost all data and discussion is limited to the period beginning in November 1989.

One of the major points stressed to the operators at Elk Island during the training period was the importance of maintaining a proper log. Emphasis was placed on the recording of all information, even if it was routine, normal, or appeared unimportant. Although records of this degree are valuable to the point of being indispensable, all operators neglect their note keeping to some extent. While the lack of some detail hampered the writing of this report, the note keeping employed by the Elk Island operators during the study period was far above the level of most small plants.

The system of records adapted for use at the Administration Site plant consisted of two major components. Daily measurements, levels and totalizer readings are recorded on a long sheet designed by B. Gray[20]. Observations, problems, measurements not allowed for on the log sheet and anything else remotely related to the operation of the plant or distribution system are recorded under dated entries in a bound notebook.

It was also strongly suggested that a third record be kept (in whatever format the operator felt appropriate) that would register complaints, positive comments or any other feedback the operator received.

Used together, this series of notes provides a flexible system that enables the operator to a record information without major inconvenience (inconvenience leads to an erosion in the quality of notes).

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[20]Appendix 10.8.

The value of quality note keeping cannot be overstated. While analysis to the extent taken in this report is a rare case, there are many possible uses for the recorded information.

The operator will routinely refer to his notes to find information on when and how past maintenance steps were taken. Closer examination of the information offers clues about problems developing in a process or piece of equipment (an example being the gradual decline of flow from a failing pump). Detailed inspection of the logs and complaints may reveal trends in water quality that may aid the operator in fine tuning his plant and fend off upsets before they occur.

One of the most valuable uses of the operator log is to track deterioration of product quality when it comes about through a gradual decline in "normal" conditions. Pressures from other demands on the operators' time, feelings of lack of recognition for continuing good work, or the simple failure to recognize a slowly developing problem may lead to a decline in produce quality.

A notable decline in the product quality from the Administration Site plant took place after the direct participation by the AEC was stopped. This decline probably had no one cause, but definitely was related to the declining effort put into the plant as other priorities diverted the operators' attention and because the reward for extra effort stopped as the project wound down.

To bring the quality of product up to its potential, and to prevent another decline, a quality-control program should be set up. An individual independent of the operational staff and their supervisors should be selected to review the quality of the product water. This person would have access to the basic operator log and be responsible for charting the major water quality parameters to detect long-term drift, as well as to review any other information available to detect upsets in operation (such as direct observation that taste, colour or clarity has changed).

Problems found would be communicated back to the operators or supervisor for attention. In the case where a persistent and solvable problem has been ignored, it may be the responsibility of the quality-control watchdog to carry the concern above the supervisor for suitable attention.

6.5 Flow and Hours of Operation

6.5.1 Hours Plant Operated

Figure 18 plots the total monthly water flow fed to the Administration Site plant in a one-year period. Month-to-month water demand from this system varied 40 per cent through this period.

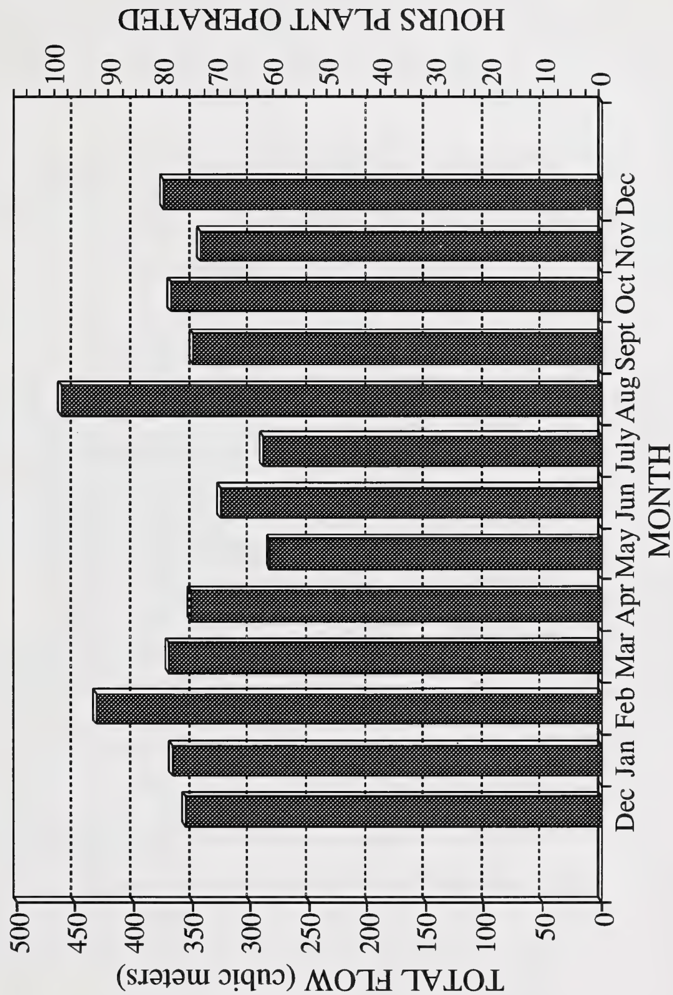
Daily flows cannot be accurately identified for this same period as there was not an outflow meter installed. Inflow data is difficult to apply to daily flow because of the intermittent nature of operations at the plant. A detailed time-of-operation analysis can be done in the future, if records are kept of the plant outflow readings. For now, an approximate estimate can be based on the inflow of water.

The Administration Site plant is fed by a progressive cavity pump. This means that the rate of pumping is relatively stable and, for these purposes, unaffected by the influence of downstream processes. Measured flow rate (recorded on the daily log) varies only between 74 and 77 L/min. The slight variance could easily be related to the flow meter and stopwatch method of measurement. Using the most commonly recorded rate of 77 L/min, it can be calculated that the plant would operate 13 minutes for every cubic metre of pumped water. Figure 18 shows hours of operation based on the above calculation, plotted on the second y-axis. On this plot, it can be seen that in May 1990, the pump ran about 59 hrs. In August, the pump ran for approximately 100 hrs.

The Administration Site water plant is normally operated two to three times a week, and in peak periods will run most days. The length of a production day varies between three and eight hours. Using these norms, August would have likely required at least 15 to 18 production days and May would have needed at least 10 operating days. The actual number of days the plant was operated were 27 (August) and 17 (May), both substantially higher than the estimates. These differences are partly the result of concern over depletion of reservoir levels.

The treated water reservoir under the Administration Site plant has a total capacity of approximately 64 cubic metres. Operating staff currently refill the reservoir when it has been reduced to 45 to 85 per cent of its capacity, but it has occasionally dropped to 20 per cent of capacity.

FIG.18. - WATER USAGE 1990
PLANT FLOW (cubic meters per month)



The reservoir does not have a fire protection role (Parks staff plan protection with their mobile equipment). Without the limitations imposed by fire protection requirements, there is an opportunity to use most of the reservoir volume to reduce the number of days of operation. The decision to use more of the reservoir capacity has to include an assessment of risk associated with loss of water from a distribution main break or loss of production from a plant equipment failure. The planner should allow flexibility to avoid problems from sporadic usage patterns and weekend flows.

An analysis of daily and seasonal flow variations from operator-collected data would be valuable to a planner taking steps to establish a standard level, or event-related levels, to signal refill of the reservoir to reduce operator time requirements.

6.5.2 Attending Operation

The Park management and staff have indicated a preference for the operation of this plant to be as "automatic" as possible. There is no reasons for the operator to be at the plant every minute of operation for every operating day. There is a minimum period of time that the operator should attend to the plant to maintain quality of product, and extra time spent with the plant improves the quality of product.

The appropriate amount of operator time to dedicate to plant operation can only be determined by the operator and his supervisor. We strongly urge that the time allotment should allow for operation-related adjustments, routine maintenance and a certain amount of process fine tuning, as well as the start up and daily monitoring routine.

Planning should reflect the fact that operation is more efficient and effective if the time allowed is regular and has a high priority (is not bumped by minor emergencies or short-term priorities), than if large blocks of time are given which are occasionally sacrificed in favour of other work.

Allowing interruptions of the operational time will cause upsets in operation. Once allowed, occasional interruptions tend to increase in frequency. Control over operation, quality expectations for "normal" operation and operator dedication all degrade if the priority given to operation is eroded. All of these effects have occurred at Elk Island in the year since AEC involvement was decreased, and will continue to occur unless the priority for operation is defined and maintained.

To aid in planning, the time allotments show in Table 5 could be used in a framework schedule for normal operating conditions. While the estimates included are only guidelines, they are reasonable for normal operation. Under conditions where a problem has arisen in the water plant, additional time would be required.

Table 5. Estimate of Time Required for Operation of the Administration Site Water Plant.		
	Operation & Daily Maintenance	
i)	Preparation and basic start up of plant	0.5 hr
ii)	Basic adjustments and bringing plant to controlled stable condition (variable)	0.5 hr
iii)	Recording levels and monitoring basic process parameters beyond what can be done during ii)	0.5 hr
iv)	Secondary adjustment of processes	0.5 hr
v)	Check up on plant after 1 hr unattended operation (varies with distance to travel)	0.5 hr
	daily operating total @ two days per week =	2.5 hr 5 hr/wk
	Weekly Maintenance	
i)	Backwash of filter (approximately 1/wk but can vary)	0.75 hr
ii)	Mixing chemicals for feed system	0.75 hr
iii)	Routine cleaning and equipment maintenance	1.0 hr
iv)	Reviewing product trends, assessing process, doing jar tests, ordering materials (all variable)	0.5 hr
	weekly maintenance total =	3 hr/wk
	Total Weekly Operator Time	
	= 7 to 10 hrs per week (to allow for seasonal variations)	

7 TREATMENT OPTIONS

7.1 Experimental Basis

7.1.1 Preliminary Study

A preliminary study[21], submitted in April 1988, contained results of a series of bench-scale tests run on Astotin Lake water in early 1988. These experiments and jar tests provided useful information on the suitability of individual processes for treatment of this water, and provided basic information on the chemical dosages required for operation of the existing plant.

Ozone and carbon filtration test results were encouraging. Based on this preliminary work, experiments were designed and run as on-site pilots in later work.

Jar tests suggested that calcium carbonate (flocculent aid) and poly aluminum chloride (flocculent) would not be useful in this case. The chemicals that were in use at the plant at the time (alum and soda ash) showed good results in the tests so were included in full-scale work and remained in the process in the working plant. More jar tests were done, under summer conditions, to establish working dosages before full-scale trials proceeded.

7.1.2 On-Site Pilot and Full-Scale Trials

Pilot work results were outlined in the Interim Report[22]. In the pilot trials, experiments were conducted on test equipment that had flow rates and scale similar to those of the Administration Site plant. Some trials involved operating the unaltered Elk Island plant, alone and in series with various process enhancements provided by the pilot system.

Work done with ozone and carbon as process enhancements has been incorporated into Section 7.3 of this report.

Experiments testing the effectiveness of filtration using filter aids as primary treatment process showed some colour removal, but not enough to reach target levels. This discourages use of this process for simplification of operations (removal of the clarifier). Use of filtration

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[21]Preliminary Study, Section 10.2.

[22]Interim Report, Section 10.3.

in this manner is still reserved for consideration if ozonation is used as the primary process of a new plant (Section 7.3.1).

After doing some jar tests to determine appropriate chemical dosages, AEC technologists operated the Elk Island plant and demonstrated that the existing plant could control the colour problem in Astotin Lake water. The runs generally produced a high-grade product water. Odour panel results were encouraging, but an odour problem with the product water after chlorination was indicated.

Several mechanical and process-related problems with the water plant caused difficulties during these trials. These problems caused uncertainties and led to the postponement of the options for odour control until the existing plant was producing up to its capabilities. Several of the physical changes suggested by the AEC following these trials were implemented by Park staff.

There are two aesthetic concerns that have to be addressed in treatment of Astotin Lake water; colour and odour. These trials demonstrated that colour can be controlled by a properly operated Administration Site plant or by ozonation. Group 4 odour problems[23] also can be controlled by either method. Group 1 odours appear to be persistent in this water. Their complete removal, without any odour reoccurrence after chlorination, may be impractical. An optimized plant, with or without enhancements, may be able to control Group 1 odours within an acceptable tolerance.

7.2 Optimization of Administration Site Water Plant

7.2.1 Process Objectives

The Administration Site plant uses what are commonly referred to as "conventional processes". The two basic steps involved are sedimentation and filtration[ref.12].

The flow pattern inside the Administration Site plant is represented as flow diagrams in Figures 19 and 20.

Water flows from the lake through a large diameter pipe to a wet well below the water plant. The wet well serves to deliver water to the plant, and doubles as a grit settling chamber.

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[23]Defined in Section 5.3.2.

FIGURE 19

ELK ISLAND - ADMINISTRATION SITE WATER PLANT
FLOW DIAGRAM

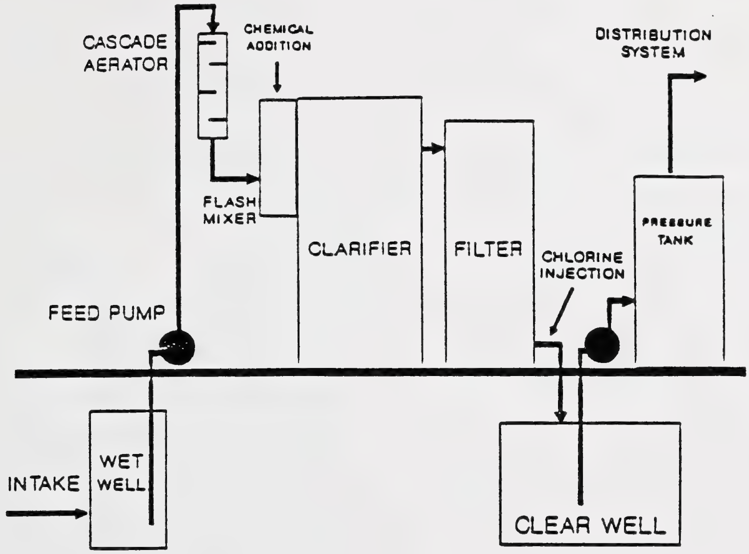
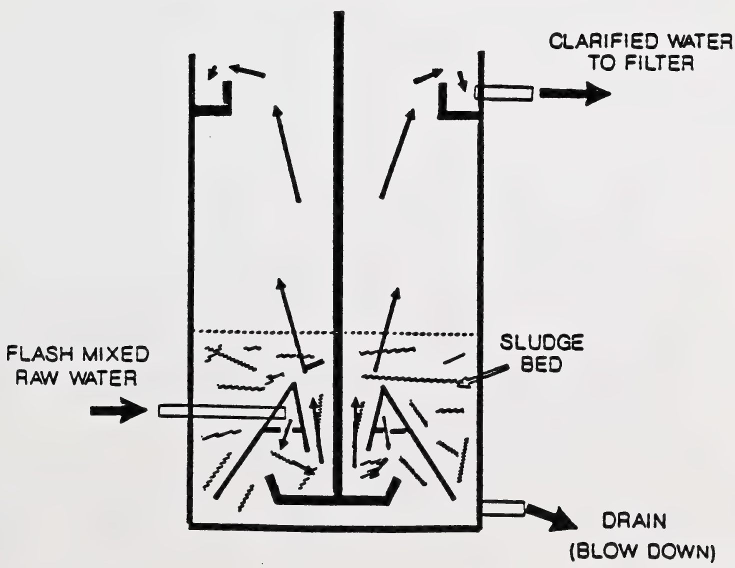


FIGURE 20

FLOW PATTERN INSIDE CLARIFIER



A positive displacement pump draws water from the wet well and delivers it to a cascade aerator to strip volitible organics. Flow then passes to a flash mixing chamber. Chemical from the stock solution tanks is added to the flow at the flash mixer by way of chemical feed pumps. The role of the flash mixer is to disperse the coagulant rapidly into the water, optimizing its effectiveness. The destabilization of particles with chemical is the primary mechanism of coagulation[ref.12].

From the flash mixer, the water with coagulant flows to an inner cone of the clarifier. Coagulation continues as the water passes through a ring channel within the cone. Conditions in the channel allow mixing to continue at a lower rate, with hydraulic energy provided by the flow. The coagulated aggregates are then carried with the water from the channel to the centre of the cone by way of four orifices.

Reduced turbulence in the larger volume of the cone allows the particles to collide and joint without causing aggregates to break up as occurs in the higher energy mixing chambers. The joining of these particles into larger clumps of material is called flocculation. The floc formed has a loose structure and is light and fluffy, almost down-like in appearance.

The floc joins together and settles to the bottom of the clarifier (settling process). This floc builds and slowly becomes more dense until some has to be drawn off to prevent overflow to the filter. This draw off, or blow down, action by the operator has to be controlled to prevent drawing off all the floc bed or breaking up the bed with the turbulence created.

In the design of this clarifier, water has to flow from the cone, down through the floc bed, and then back up through the bed outside the cone to reach the overflow trough. Passing through the flock bed enhances the flocculation and settling process by physically trapping already formed floc and providing laminar flow conditions that encourage further flocculation. A dense, mature flock bed produces the highest quality water. This is why blowing down of the clarifier should be minimized during plant operation.

Clarified water flows from the collection trough to the top of the gravity filter. The sand media physically strains material escaping the clarifier and provides a surface to which smaller material, that has been charged and destabilized by the treatment chemicals, can adhere. The primary measure of the filter performance is turbidity.

Water passing from the bottom of the filter is chlorinated by a liquid chlorine injection pump. Injection of the sodium hypochlorite by the feed pump is regulated by signals sent from a water meter, which can stop or change the feed rate in response to flow.

7.2.1.1 Clarifier Problems

Problems with plugging inside the channel structure and orifices of the clarifier cause alteration of flow patterns within the clarifier. This impairs the ability of the clarifier to remove the particulates responsible for colour and other undesirable qualities of the source water. A poorly formed floc bed, or no bed at all, leads to separation, suspension and overflow of floc to the filter. The filter plugs quickly under these conditions, increasing the backwash frequency.

The existing sample points are not ideally located. The sample lines are generally perforated by corrosion and need to be replaced. Lack of the type of information provided by proper sampling blinds the operator to the conditions inside the clarifier. While the clarifier can be operated within the limited sampling currently available, consistently achieving optimum conditions is unlikely, and upsets in operation are to be expected.

Generally, process problems can be controlled by a skilled operator with time to spend on the problem. Physical problems with the Administration Site plant clarifier cost additional man-hours when the effort is made to maintain a high-quality product.

7.2.2 Polymer

While operating the Administration Site water treatment plant during the training period, AEC technologists identified a process problem where the floc bed in the clarifier would float to the top after a period of time.

The origins of this problem were unclear, but speculation centred on a changing temperature in the clarifier and on the composition of the floc bed. Temperature stratification would likely occur when cold raw water is pumped into the bottom of the clarifier, with the tank full of water warmed from sitting between days of operation. A light floc bed would tend to float at the interface between the warm water already in the clarifier and the denser, cold, raw water.

The particulate load (primarily silt and algae) is lower in Astotin Lake water during the months of ice cover. As a result, a floc bed formed in this water will be lighter in the winter

than in the summer. As these are also the months with the coldest raw water, the flotation problem is amplified and occurs more frequently.

It was reasoned that little could be done to correct the temperature stratification in the clarifier since the plant is to be operated in an intermittent mode. Draining the clarifier between runs would cause the loss of a developed bed, greatly increasing the time needed to start up production.

Attention was directed toward changing the density of the floc bed. To increase the density of the floc, AEC technologists explored the addition of flocculant aid to the clarifier. An anionic polymer called Praestol 2540[24] was selected for testing. Choice of this polymer was largely the result of the AEC having a large amount of that polymer on stock, and the product being available from a Canadian distributor.

An initial dosage of Pr 2540 was determined, based on positive results in a jar test. A temporary feed system was set up with AEC equipment, and polymer feed was started to the clarifier. Operators found that the stock solution tended to thicken over time, to a point where the pump was unable to deliver the solution to the clarifier. This problem was overcome when the stock solution was diluted.

Addition of polymer caused the flock bed to become slightly denser and the floc tended to hold together better. Flotation of the bed still occurred occasionally, but with a more acceptable frequency.

Elk Island operators found that the polymer feed could be stopped during the summer months without major flotation problems. There may be an advantage to continuing addition of polymer through the summer months, possibly at lower dosage rates. The polymer may serve to stabilize the floc and reduce the number of upsets in the clarifier.

The AEC-supplied polymer feed system was left in place for two winters of operation and has only recently been removed. The operators chose to operate for much of the winter of 1990-91 with the polymer shut off, and suffered multiple operational upsets. A permanent feed system should be installed before the winter of 1992 for cold water operation.

Polymer has been supplied by the AEC for daily operation until the writing of this report. There has been little effort made to locate a product that would provide optimum performance

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[24]Bayer Canada Ltd.

with the Administration Site plant clarifier. Performance could benefit from more careful selection of a polymer when it comes time to purchase more chemical.

Chemical supply companies are usually willing to provide samples of their products (the amount of polymer required for operating this system is under 20 g per week, and a typical sample could be as large as 50 g). A series of jar tests could be used to narrow the range of choices and to determine dosages. Likely products could be tried in the plant without seriously disturbing operations.

The AEC is available to advise the operator when he is going through the selection process.

7.3 Alternative Technologies

7.3.1 Ozone

During the early contacts with Parks Canada, interest was expressed about the possibility of using ozone to alleviate the problems with water quality being experienced at Elk Island.

Preliminary work with ozone treatment showed good colour reduction (colour was the primary concern in early work). Based on the positive early results, the initial requests by Parks Canada, and the agreement reached outlining the course of study, ozone as a treatment option for Elk Island was investigated extensively.

Between March 1988, and July 1990, 17 bench tests using ozone were conducted on Astotin Lake water.

The ozone bench tests were designed to measure the amount of ozone demand (the amount of ozone consumed by a sample of water) of the test water. Measurements of colour and residual ozone were taken from coincident samples. These data were used to compare colour removal to the ozone uptake characteristics for each sample.

Ozone demand and colour reduction information is useful in determining the suitability of ozone treatment, and would aid in sizing an ozone plant if this option were chose.

In addition to the bench work, field work included 12 flow-through system runs in which ozonation of raw lake water was observed, as well as five runs combining ozonation and filtration and two runs pairing ozone with the existing Administration Site plant. One other run tested the effectiveness of ozonating raw water and then polishing it with a carbon filter.

Product water from several of the above field trials was presented to Park staff odour panels for evaluation. Results have been incorporated into the related discussions.

The flow-through system work complements the bench work and is covered later in this section.

7.3.1.1 Treatability of Astotin Lake Water with Ozone

The series of ozone demand experiments on Astotin Lake water provide a record of the change in ozone demand over time. Because of the nature of ozone demand, they can also be viewed as an index of the variation in raw water quality over the study period.

For purposes of this discussion, the results of the ozone demand experiments have been divided into three seasons. These results have been summarized in Table 6. Each recorded demand number is the result derived for a 30-minute experiment where ozone was fed to a batch sample of water while feed gas, off gas and dissolved residual ozone concentrations were monitored. Setting up, running the experiment and performing lab analysis of samples required approximately two man-days.

The demand figure represents all the ozone (in milligrams) that was consumed in one litre of sample, minus the system-related losses and the ozone retained as a residual. Data from Table 6 are plotted as Figures 21, 22 & 23.

The winter season (Dec., Jan., Feb.) has been found to have the highest quality raw water and requires the lowest amount of ozone to treat. The winter ice cover conditions produce calm, cold water when particulates settle and biological growth is minimized.

Spring turnover of the lake stirs up sediments from the lake bottom, while snow melt runoff and groundwater feed bring additional material into suspension in the lake. The increase of this suspended material increases the demand for ozone.

Summer conditions promote biological growth in the lake, producing ozone-demanding materials. Rough weather stirs up additional sediment, further increasing the demand in the water. These demand-causing conditions slow down in the fall, but late fall turnover of the lake again deteriorates conditions.

While the average demand and colour conditions for the spring and summer/fall seasons are similar, and the conditions noted above blend together and are not sharply defined, dividing the two seasons acknowledges the difference in the primary demand-causing conditions. Lake

Table 6. Ozone Demand in Astotin Lake Water Summary of Test Results Summarized by Operating Season.

Date of Test	Demand Measured (mg/L)	Turbidity (NTU)	Apparent Colour (CU)	Actual Colour (CU)
#1 - Winter Season				
Jan. 24, 1989	6.9		38	14
Feb. 17, 1989	9.1	2.4	39	12
Dec. 19, 1989	10.0	3.2	40	12
Jan. 23, 1990	9.3	2.5	29	19
average	8.8	2.7	37	14
#2 - Spring Season				
Mar. 24, 1988	12.4		81	15
June 20, 1988	16.1	8.3	70	12
March 1, 1990	25.0	4.7	52	16
May 8, 1990	29.0	3.9	58	13
June 11, 1990	17.3	5.6	87	16
average	21.3	5.1	67	15
#3 - Summer/Fall Season				
July 29, 1988	13.2		75	25
Aug. 16, 1988	34.0	6.6	113	16
Sept. 26, 1988	25.5	6.2	104	10
Oct. 18, 1988	13.9		72	18
Oct. 26, 1989	28.5	3.7	96	21
Nov. 21, 1989	22.5	3.4	57	10
July 30, 1990	20.0	4.4	73	25
average	22.5	4.9	84	18

water taken during the worst summer conditions produces the least aesthetically appealing treated water quality in all of the treatment processes investigated in this study.

7.3.1.2 Ozone Demand

Summarizing results from the ozone demand runs, it can be generalized that the demand for ozone in Astotin Lake water is in the order of 22 mg/L, with a lower demand of 9 mg/L in the winter months and short-term year-round variations ranging from 7 mg/L to over 35 mg/L.

FIG.21. - ASTOTIN LAKE WATER
OZONE DEMAND vs TURBIDITY (avg. values)

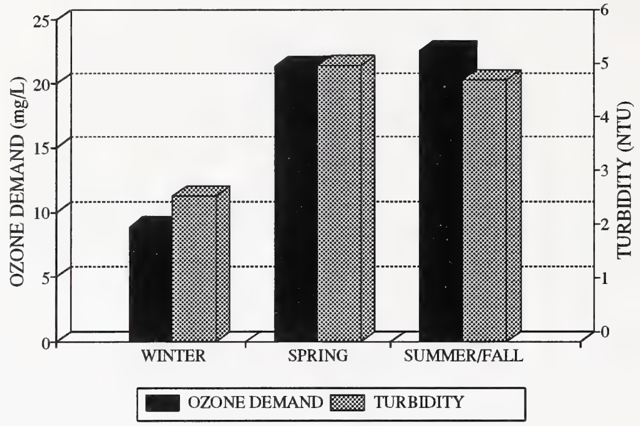


FIG.22. - ASTOTIN LAKE WATER
OZONE DEMAND vs APPARENT COLOUR (avg.)

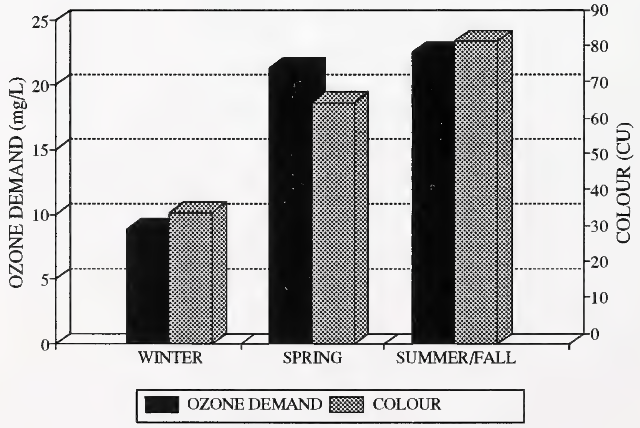
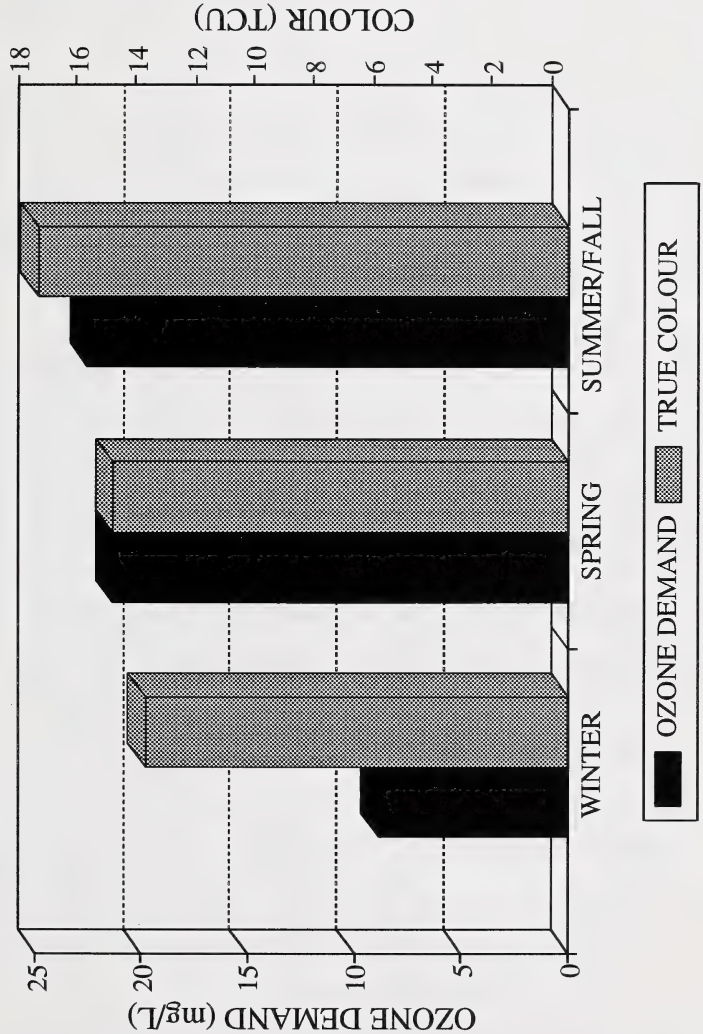


FIG.23. - ASTOTIN LAKE WATER
OZONE DEMAND vs TRUE COLOUR (avg.)



The ozone demand tests were performed by supplying ozonated air to a batch reactor column. Ozone was monitored in the supply and off gas. Dissolved ozone residual was measured in samples taken from the column. To determine the total demand of the water, a mass balance was attempted.

Figure 24 graphically shows the balance of ozone in gas during a single demand experiment (in this case July 31, 1990). The heavy dotted line represents the feed rate of ozone to the test column, the dashed line shows the increasing rate of ozone passing off the column and the solid line is a calculated value for the ozone feed rate. The calculated feed rate takes into account the system and temperature-related losses. The area between the solid and dashed lines represents the demand for ozone in this sample.

During a demand run, the feed rate is held relatively constant (a slight downward drift in the illustrated run). The rate of ozone passing in the off gas increases with time as the demand for ozone in the water decreases and the resulting rate of consumption slows. This produces a characteristic, declining rate curve that is determined by the rate and concentration of feed gas as well as the water volume and type and quantity of ozone-consuming components present in the sample. By maintaining constant experimental conditions, the only variable that significantly changes the area under the curve is the demand for ozone in the water.

7.3.1.3 Colour Reduction with Ozone

Figure 25 plots the reducing demand for ozone in the July 31, 1990 sample (solid line) against the reduced apparent and true colours of the water during the run.

It can be seen that the bulk of the colour reduction is achieved in the first three or four minutes of this run, more than ten minutes before the full demand of 20 mg/L has been applied and the sample stops consuming ozone.

The early reduction of colour was also seen in the series of field trials conducted with a flow-through system (mobile treatment plant)[25] in the summer of 1988. These results are summarized in Figures 26 and 27. These graphs illustrate reduction of both apparent and true colour, with the most dramatic drop occurring with consumed doses below 10 mg/L. While the

[25]Trials conducted on the Administration Plant site, 1988.

FIG.24. - ASTOTIN LAKE WATER, JULY 1990
OZONE DEMAND TEST - 0.6% OZONE FEED

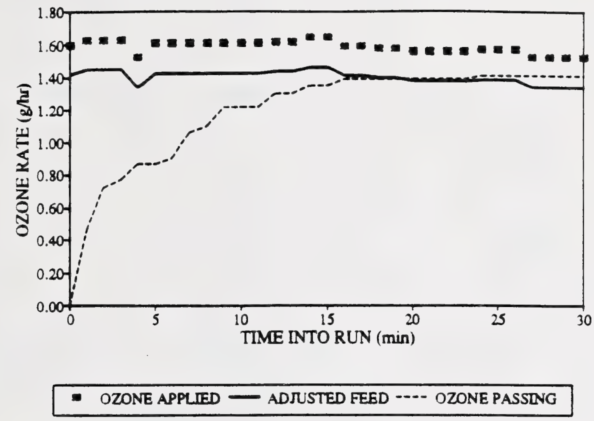


FIG.25. - ASTOTIN LAKE WATER, JULY 1990
COLOUR vs OZONE CONSUMPTION

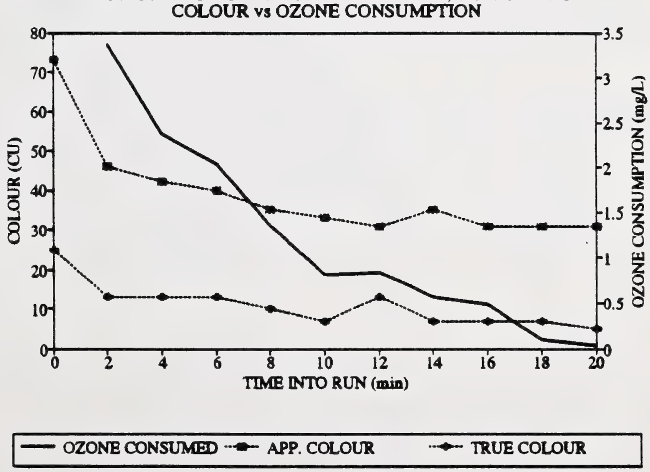


FIG.26. - FIELD TRIALS - SUMMER 1988
TRUE COLOUR REMOVAL WITH OZONE

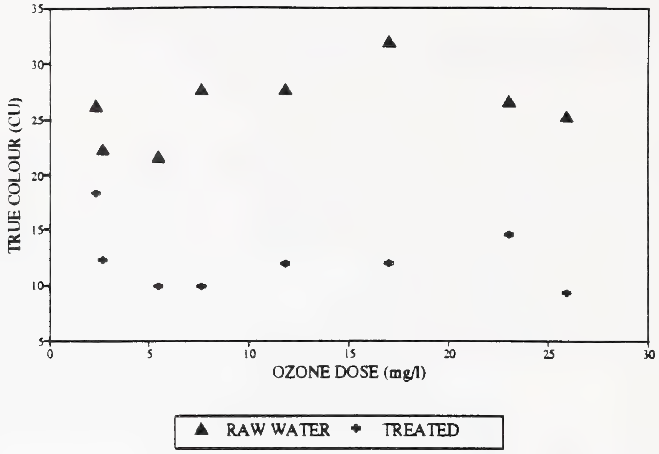
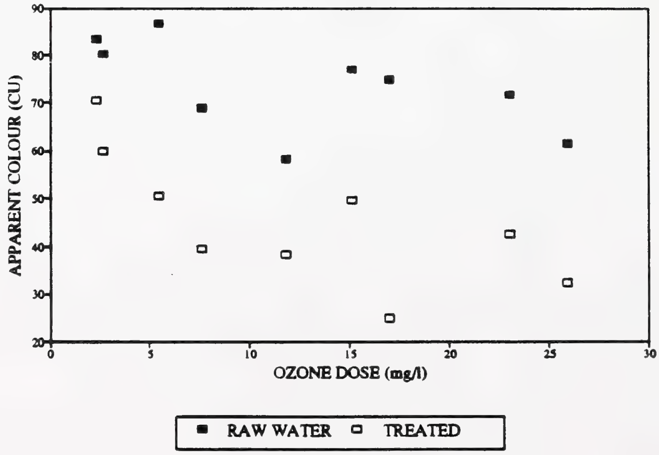


FIG.27. - FIELD TRIALS - SUMMER 1988
APPARENT COLOUR REMOVAL BY OZONE



total consumed-dose demand in these samples was between 15 and 25 mg/L, further addition of ozone above the 10 mg/L level was of limited value.

This evidence suggests that if an ozonation system were to be designed for treating Astotin Lake water for colour, nearly optimum results could be achieved at contacted dosages below 20 mg/L, and as low as 10 mg/L. Note that reported values are contacted dosage (consumed dosage minus system loss). Applied dosage depends on contact efficiency and design factors. As such, it is not a useful measurement to report. Also note that ozone generator should be sized conservatively to allow for a decrease of production with time (normal) and changes in water quality (environmental factors). Caution should be exercised when purchasing this type of system since some sales people working in this field have been known to over-represent their products.

Table 7 summarizes the bench-scale demand experiments. Included are derived values for demand, raw water colours, and the colours measured after the sample was ozonated to the demand dosage. Also shown are the colour values recorded after ozone was applied for several minutes (average approximately 15 minutes) after the ozone demand was satisfied. The results produced by overdosing ozone show that further significant reductions of colour occur only in a few cases.

The true colour values (from Table 7) for Astotin Lake water dosed to demand are plotted in Figure 28. In all cases, the Canadian Drinking Water Guidelines[ref.2] aesthetic objective of ≤15 TCU has been met by ozonation.

Figure 29 plots apparent colour from the same set of data. In almost all but the lowest demand samples, apparent colour remains over 20 CU. Values of apparent colour in this range suggest that while ozonation of Astotin Lake water effectively removes true colour to target levels, some colour may yet be detectable by the human eye. This is caused by "filterable" material.

Figure 30 plots the value for reduction in apparent colour (raw water colour minus treated water colour) against the reduction in true colour, for samples taken from each of the ozone demand runs. By comparing the reduction in the two types of colour, it can be seen that the reduction in apparent colour is greatest. This indicates that ozone is oxidizing, or otherwise changing, much of the material in particulate form in addition to the oxidation of dissolved material.

Table 7. Colour Reduction by Ozonation Ozone Demand Runs.

Date M/Y	Ozone Demand (mg/L)	Initial Colour (CU) App.	/ True	Colour (CU) At Demand Dose App.	/ True	Colour (CU) Beyond Demand Dose App.	/ True
March/88	12.4	81	15	29	5	29	5
June/88	16.1	66	13	23	7	23	5
July/88	13.2	75	25	25	10	23	12
August/88	34.0	113	16	53	8	55	8
September/88	25.5	104	10	40	<10	23	<10
October/88	13.9	72	18	25	5	18	3
January/89	6.9	38	14	<10	<10	<10	<10
February/89	9.1	20	12	12	10	10	10
October/89	28.5	96	21	30	10	34	10
November/89	22.5	57	10	30	<10	25	<10
December/89	10.0	40	12	18	8	21	7
January/90	9.3	29	19	19	14	23	16
February/90	25.0	52	16	8	5	5	4
March/90	28.0	55	20	23	7	10	5
May/90	29.0	58	13	18	10	18	5
June/90	17.3	87	16	35	5	35	5
July/90	20.0	73	25	35	10	31	5

Separation between the two types of colour data in Figure 30 is confirmed by comparing the mean values and standard deviations for demands over 10 mg/L demand (app. colour, mean = 47.6, std. = 9.4; true colour, mean = 10.5, std. = 3.5).

Figure 31, represents several ozonation/sand filtration trials done on the flow-through system during the Elk Island field trials. All four trials were done with similar ozone dosages. The post-filter data are plotted as per cent removal of the colour values measured after ozonation.

FIG.28. - OZONATED ASTOTIN LAKE WATER

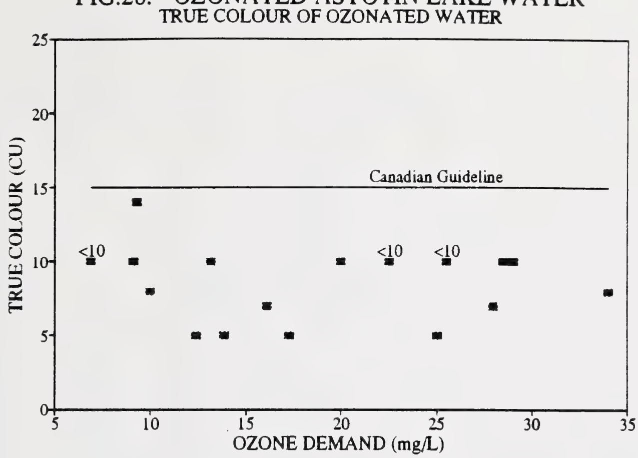


FIG.29. - OZONATED ASTOTIN LAKE WATER

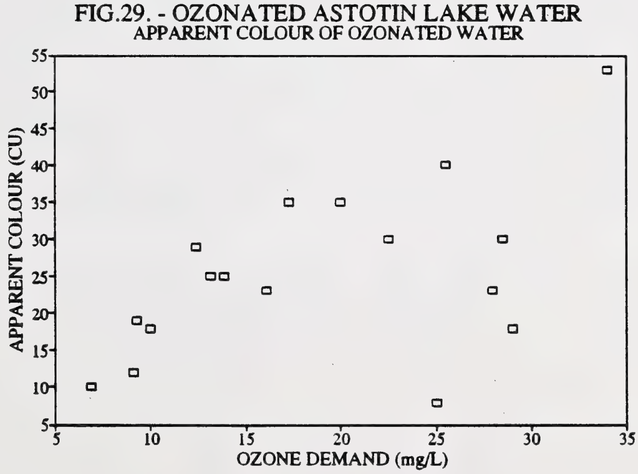


FIG.30. - OZONE DEMAND EXPERIMENTS
COLOUR REMOVED BY OZONE

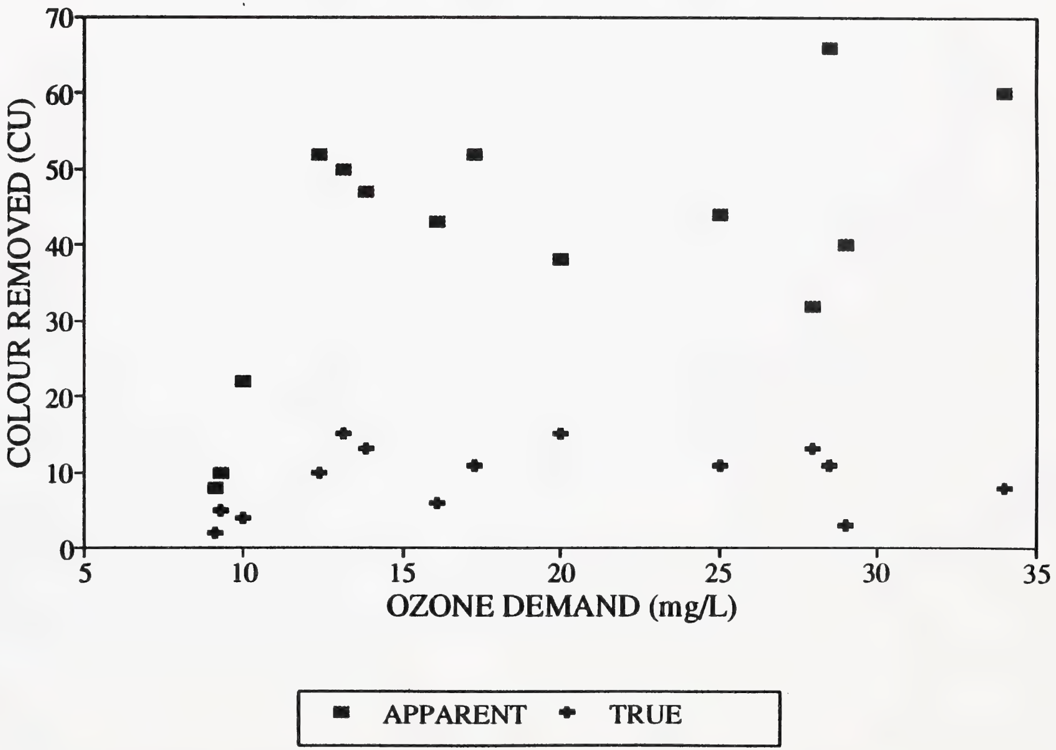


FIG.31. - FILTRATION OF OZONATED WATER
COLOUR REDUCTION BY OZONE + FILTRATION

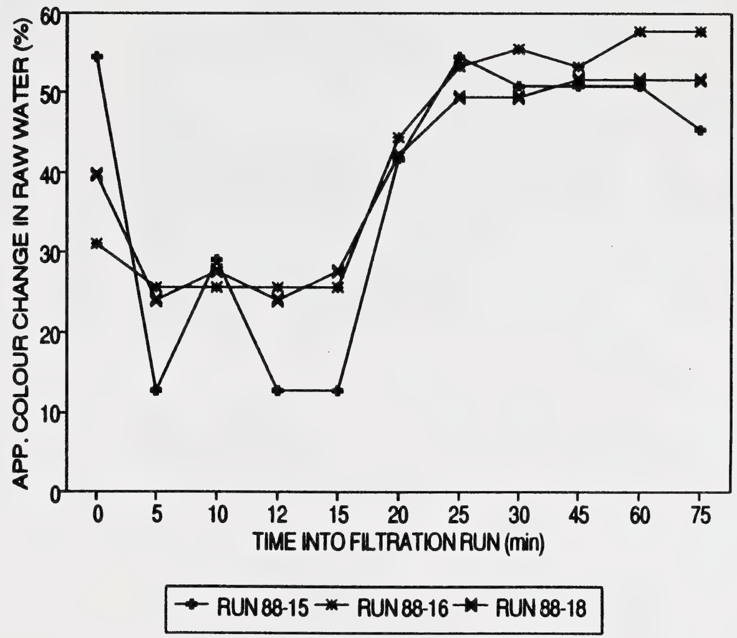


Figure 32, shows the same runs as per cent removal of the raw cold value. No reduction of true colour occurred as the result of filtration in these trials. Filtration with carbon (Run 88-21, notrepresented here) produced similar reductions to those achieved with sand for both apparent and true colours.

The results show that the combined ozonation/filtration process can remove 60% of apparent colour in Astotin Lake water. A properly cured filter can remove 40% of the apparent colour remaining after ozonation. Apparent colour of up to 40 CU was still present in the product water after ozonation and filtration, but further reductions may be possible if the filtration process were optimized with filter aid.

Some discussion contained in this report is based on comparisons between apparent and true colour values. It should be noted that measurements of true and apparent colour use the same units, but differ by pre-treatment of the samples. True colour involves filtering the sample and then adjusting it to a standard pH before reading the colour. The pH adjustment step can alter the colour of the sample. During the demand runs, and in other parts of this study, the AEC Process Control Lab took a third colour measurement in addition to apparent and true colour. In this measurement, the sample was filtered (as in true colour) and read without pH adjustment.

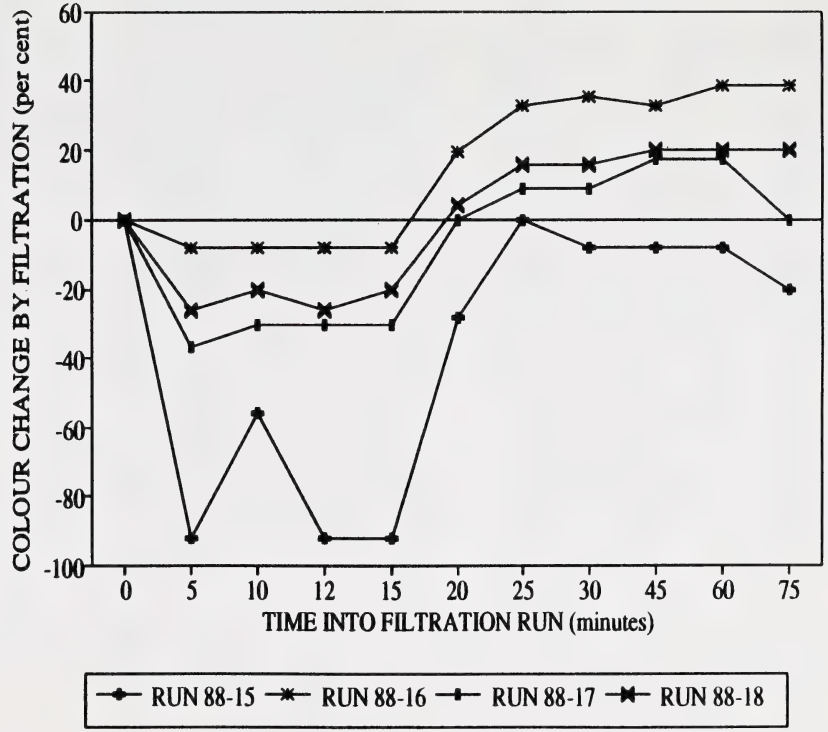
In the 112 directly comparable samples from the ozone demand study, the sum of the true colour measurements was found to read 98.2 per cent of the sum of the filtered sample values on raw water samples. In ozonated samples, true colour totalled 90.2 per cent of the filtered sample total.

While colour change by pH may affect comparison of individual values in the related figures, the average error for the samples measured in this set is under 10 per cent and should not affect the conclusions made in this report.

7.3.1.4 Ozone Supplement to Existing Plant

The Ozone Treatment Research Trailer was used in runs where the entire throughput of water to the Administration Site water plant was pre-ozonated or post-ozonated. To accomplish pre-ozonation, lines were connected to divert flow from the main water plant feed pump through the ozone trailer. Ozonation water was then fed to the clarifier flash mixer by way of a pump located in the trailer. Post-ozonation was accomplished by collecting water after it had been

FIG.32. - FILTRATION OF OZONATED WATER
APPARENT COLOUR REDUCTION BY FILTRATION



treated in the unaltered Administration Site plant system, and pumping it to the trailer's ozonation columns.

Figure 33 represents a 30-hour trial where pre-ozonation at an ozone dose of 3 mg/L was added to the Administration Site plant treatment train. The solid squares represent the apparent colour in the raw water during the run (above-normal colour for this raw water) and the empty squares represent the product of the combined processes. Post-ozonation colour has also been included in this plot.

Figure 34 shows results of a similar trial where the Administration Site plant was operated (clarification and filtration) without supplemental treatment.

Stability of the apparent colour in the product water appears to be better controlled with pre-ozonation, as does true colour (Figures 35 and 36). All recorded true colour values for product water are below 15 TCU. Most recorded values, in both trials, approach the detection limit of 5 TCU.

Figures 37 and 38 trace the measurements of turbidity for the same runs, and again show less stability in the Administration Site plant without pre-ozonation. The high turbidity of the ozonated water, in Figure 37, suggests that flocculation, or microflocculation, may be occurring after ozonation. High turbidity in the clarifier outflow, in Figure 38, results from floc passing to the filter and occurs when conditions in the clarifier are less than optimum.

Based on the results from these two trials, pre-ozonation appears to enhance the turbidity and colour quality of the Administration Site plant product to very acceptable levels. Low turbidity product was produced with, and without, pre-ozonation. The Administration Site plant did not consistently produce low apparent colour throughout the ozone-free run, but did achieve <15 CU levels for several hours. This suggests that process optimization may produce water quality close to that attained in the pre-ozonation trial.

Data from a separate set of trials where Administration Site plant product water was post-ozonated and carbon filtered as polishing steps has been used to create Figure 39. In these runs, Elk Island plant product water was of high quality, showed no improvement in apparent colour reduction with ozonation, and a small improvement through carbon filtration. This suggests that polishing the product water may not be required for colour removal if the conventional plant were functioning properly.

FIG.33. - FIELD TRIALS - COLOUR REMOVAL
PRE-OZONATION - ADMINISTRATION PLANT

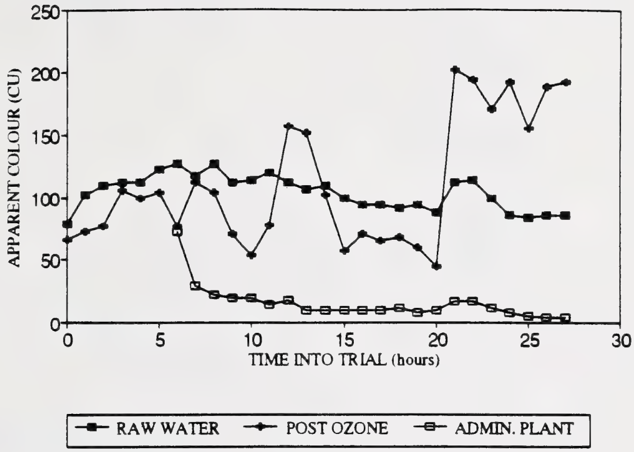


FIG.34. - FIELD TRIALS - ADMIN. PLANT
AEC TRIAL, 1988 - APPARENT COLOUR

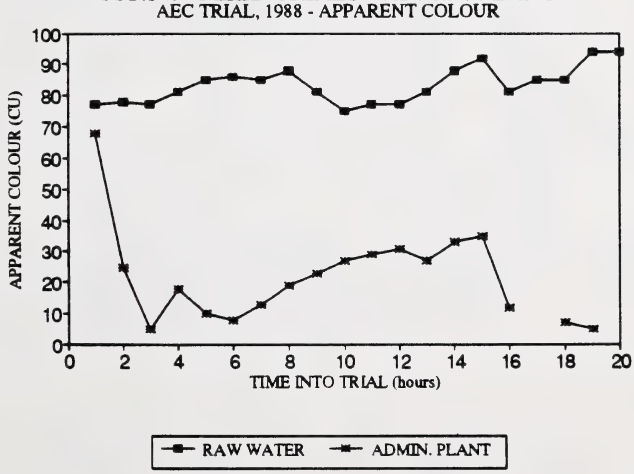


FIG.35. - FIELD TRIALS - TRUE COLOUR
PRE-OZONATION WITH ADMINISTRATION PLANT

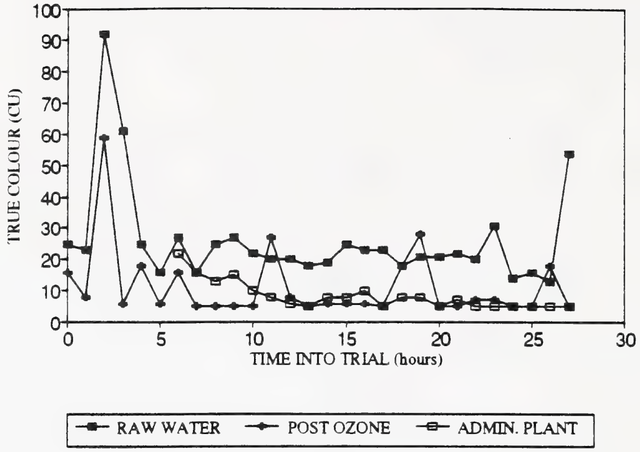


FIG.36. - FIELD TRIALS - ADMIN. PLANT
AEC TRIAL, 1988 - TRUE COLOUR

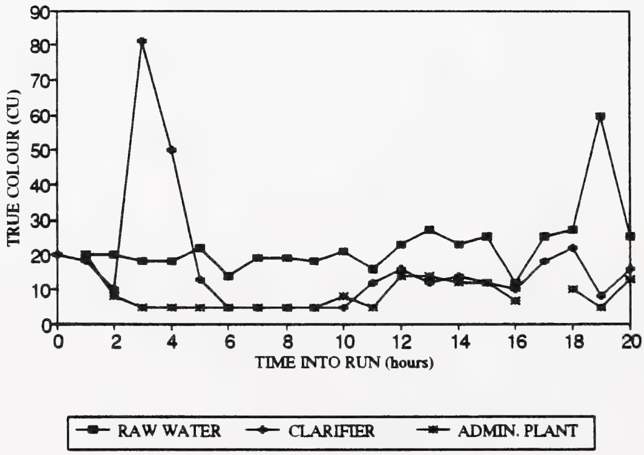


FIG.37. - FIELD TRIALS - TURBIDITY
PRE-OZONATION WITH ADMINISTRATION PLANT

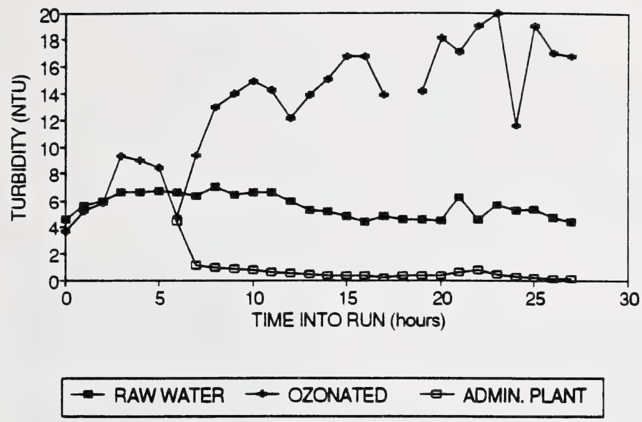


FIG.38. - FIELD TRIALS - ADMIN. PLANT
AEC TRIAL, 1988 - TURBIDITY

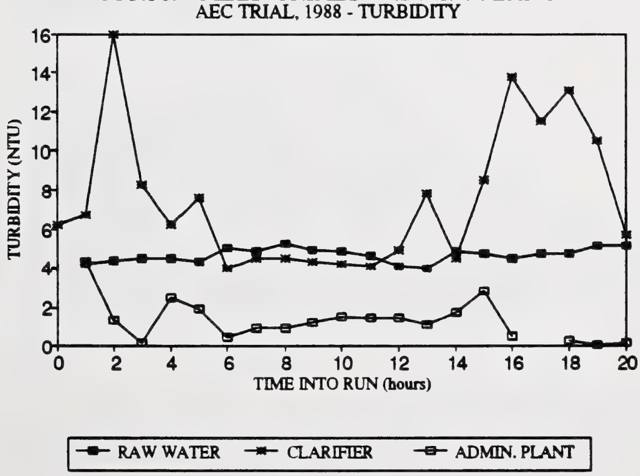
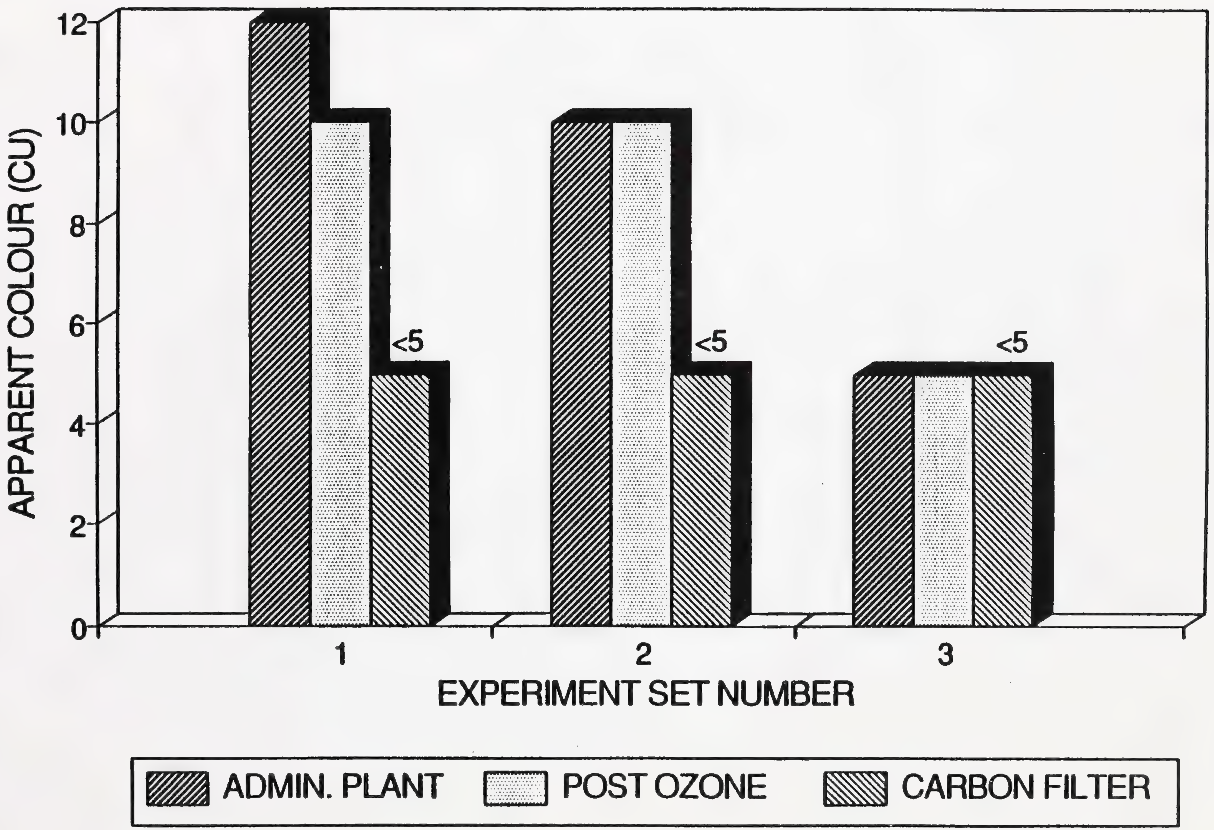


FIG.39. - FIELD TRIAL - APPARENT COLOUR
ADMIN. PLANT, POST OZONATION, G.A.C.



7.3.1.5 Ozone and Odour Reduction

Ozone is volatile and dissipates quickly from water. Unlike chlorine, the distinctive odour of ozone cannot be detected after a relatively short time and likely would not be detectable to consumers supplied through a distribution system such as at Elk Island.

Informal odour tests were conducted on water ozonated in the demand experiments. It was found that the "musty/sloughy" odour present in the Astotin Lake raw water was absent. In its place was a faint, but distinct, hard-to-describe odour with characteristics likened to synthetic odours. Odour descriptions varied and included: plastic; chemical; rubbery; vanilla; and sickly sweet.

The offending odour was not apparent in cold water and only appeared in warmed water tests. Longevity of the odour was not determined.

Similar odours were encountered during ozone testing by the City of Edmonton[ref.5]. These odours contributed to the postponement of further experiments with ozone there, and to the recommendation that future work should use ozone supplemented by additional treatment (biofilters or advanced oxidation processes).

Cool ozonated product water (in various combinations with other processes) was included in tests using Park staff odour panels. The ozonated product fared well in that testing, but odours became detectable after the addition of chlorine.

7.3.2 Carbon

Activated carbon is commonly used for removal of organic materials in water treatment processes. Many colour, taste and odour-causing materials, as well as the precursors for trihalomethanes, are organic.

Several methods of carbon application are used. These include addition of powder carbon to clarifier feed water, addition of powdered carbon to sand-filter feed water and filtration using granular activated carbon.

A powdered carbon feeder is installed in the Administration Site plant. This feeder was installed in 1966, in an attempt to reduce colour, taste and odour in the treated water. The feeder was abandoned after powdered activated carbon was found to be ineffective in reducing the problem. The lack of success with powdered carbon might have been due to choices of feed location, dosages and even the type of carbon selected. Nonetheless, we were reluctant to

experiment with powdered carbon during this project. Powdered carbon is dusty and creates unpleasant working conditions unless specially handled. Operation of the current carbon feed installation would likely lead to hygienic problems in the plant.

Originally the powder feeder may have been used for continuous addition of carbon to the clarifier feed water. This approach is reasonable because the organic loading on the plant is reduced early in the treatment train. However, the original set-up would have had a problem with the chlorine injection point located soon after the carbon addition point (carbon removes chlorine from the water).

The AEC did not do pilot work with powdered carbon in this study. While early work did indicate that fresh carbon was very effective for colour removal in raw water[26], lower cost and manpower requirements, as well as more consistent product, were anticipated by using carbon as a polishing step after treatment. As a result, our work with carbon was focused on the polishing step.

Most of the early bench and field work with carbon was directed at colour removal. After adequate colour removal was demonstrated with the existing plant, attention shifted toward taste and odour problems.

The first experiments on taste and odour removal with carbon were conducted during the August 1988 field trials. Runs were done at the Administration Site plant using pre-ozonation, post-ozonation, and each of these processes with and without a carbon filter polishing step. Water from all four runs was given good ratings from the taste and odour panel, but was rated lower after the waters were chlorinated.

In the summer of 1989, a carbon test filter was built at the AEC and installed in the Administration Site plant. Water was diverted from the main flow (out of the plant's sand filter) and fed to the test filter by way of a solenoid valve. The solenoid was controlled to operate the filter synchronous by the main plant. There were some problems controlling the rate of flow through the filter, and the life of the carbon was likely shortened somewhat by the tendency for flow to be higher than the designed rate.

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[26]Section 10.2, Preliminary Study.

In initial samples, and those taken after the first week of operation, the test filter reduced odour substantially and little or no odour was apparent in the product water[27]. After the fourth week of operation, odour removal had dropped to a point where the odour in the post-carbon sample was noticeable. The improvement in odour was still noticeable when pre- and post-carbon samples were compared, but the type of apparent odour was common to both samples.

The relative short life of this test filter indicates that a permanent carbon filter installation in this location would likely require frequent changes of carbon to remain effective. Changing carbon in a filter sized for this plant would be costly enough to discourage frequent changes, and would be labour intensive.

To investigate the effectiveness of the point-of-use cartridge carbon filters installed in most of the Administration Site buildings, a fresh carbon element was installed in an existing housing located in the Warden's office building. The housing was located on the feed to a sink that was thought to be heavily used (the actual usage at the sink was later found to be lighter than expected).

Odour checks on the product from this filter found that samples taken immediately after installation had good (not excellent) odour removal when compared to the cartridge feed water. Samples taken one week after installation were found to have slight, but easily identifiable, "musty/earthy" odours present. Based on available reference material, the ability of carbon to adsorb geosmin and methylisoborneol (the two chemicals most often associated with this type of odour) is reduced in the presence of free chlorine or monochloramine[ref.10].

This poor performance, the potential problems caused when carbon removes chlorine residual from the water, and the maintenance problem of ensuring regular changes of elements in private residences, are sufficient reasons to discourage the use of these cartridges. To ensure that improperly maintained filters do not reduce the biological purity of the drinking water, the housings located in the residences should be removed.

Since carbon filtration before chlorination appears to be effective but short lived, it was decided to try cartridge carbon filtration on the main treatment train as a low-maintenance alternative.

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[27]Odour testing done by AEC staff with warmed sample.

A system for housing carbon filters was built at the AEC. It was then dismantled and given to the Elk Island staff for installation at a point after the sand filter in the Administration Site treatment train. Installation was completed in fall 1990.

Initial carbon filter results were good, but problems with plugging in the pre-filter system altered operation and limited the flow through the filters. As a result, an estimate of the life span from the first element set was not possible.

An agreement with the Elk Island staff made purchasing and element replacement a park responsibility. Unfortunately, as of April 1991, the plant was still running on original filter elements. In an April contact with the Elk Island operator, it was re-emphasized that elements should be changed for the test to work.

7.3.3 Slow Sand Filtration

Use of slow sand filtration for potable water treatment dates back to the early 1800s. Its use declined with the development of new technologies, but interest in slow sand filtration has increased in recent years.

A slow sand filter shares much of its design with rapid rate filters (a rapid rate filter is used in the current Administration Site operation). Design differences between the filters include size, rate of filtration and the absence of backwash equipment in slow sand filters.

Slow sand filters are generally designed to operate at 0.05 to one gallon per minute per square foot of surface area. In comparison, rapid rate filters run at one to three gallons per minute per square foot and can run at ten gallons per minute with some mixed media applications.

A slow sand filter works by trapping and biologically removing or altering materials from the feed water. Most of this activity occurs in a biological layer that forms on the surface of the sand bed. This layer is referred to as the schmutzdecke.

Maintenance of this type of filter involves daily observation of water quality, adjustment of water levels, and occasional scraping of the filter. Scraping is done when the hydraulic head loss becomes too great and usually involves the removal of the top inch of the filter bed. Eventually, enough sand has been removed from the filter to necessitate the addition of fresh sand.

The advantages of using slow sand filtration often include: reduction of chlorine dosage requirements as some demand-causing materials are consumed in the filter; reduction in trihalomethane formation potential; reduction of colour, taste and odour in water; manganese reduction; simple operation, including elimination of some of several treatment steps in a plant.

The disadvantages may include: excessive algae growth on the filter; long recovery period after upsets in operation (weeks to months before water quality recovery, longer periods if problems occur in the winter); addition of water quality problems if the algae growing on the sand are an undesirable species.

Slow sand filtration can be included in the options for Astotin Lake application since the lake water normally has a turbidity below 10 NTU, meeting the main requirement for this technology to be used.

The size of filter required in this application would be in the order of 60 square feet in surface area. This is twice the diameter of the current filter. Flow patterns in the plant would have to be altered to provide continuous feed since intermittent operation interferes with the effectiveness of the process.

In an AEC review of available literature, it was found that the focus of slow sand filtration work has been on turbidity and pathogen removal. References concerned with colour, taste and odour reduction describe good to mixed results. No experiences with water resembling the Astotin Lake source were found.

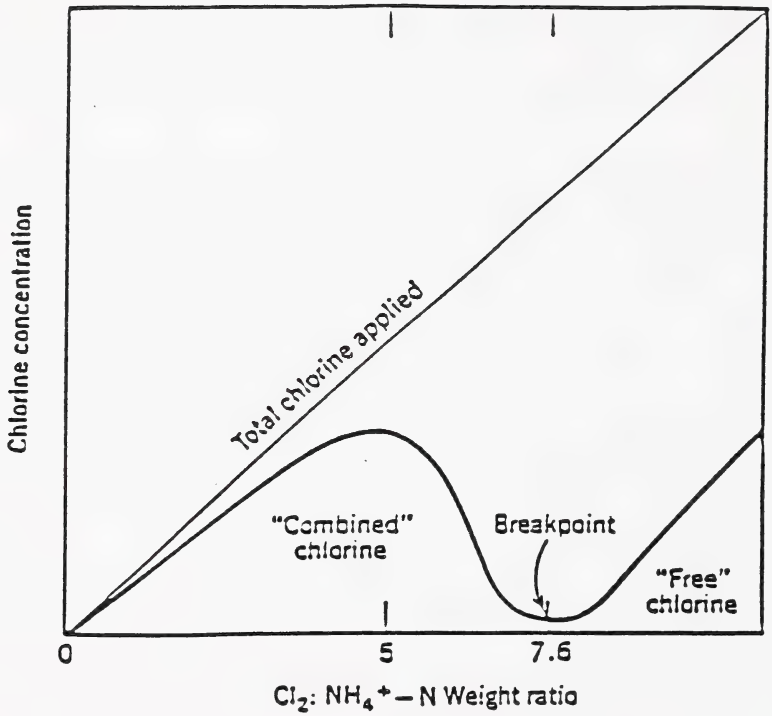
If slow sand filtration is explored as a possible enhancement or replacement in the Elk Island plant, a carefully controlled pilot test should be set up. Such a test should run two years for complete assessment.

7.3.4 Breakpoint Chlorination

A typical breakpoint chlorination curve is demonstrated in Figure 40. The figure plots added chlorine vs measured free chlorine residual in a sample water. It can be observed that increasing the does of chlorine in a water sample will cause a proportional increase in measurable chlorine residual until a point has been reached where the level of residual suddenly drops, before climbing again.

FIGURE 40 Breakpoint Chlorination Curve

From Water Treatment Principles & Design,
J.M. Montgomery Engineers Inc., 1985



The breakpoint observed in this style of curve locates a change in the chemistry of the water and identifies a dosage where chlorine has oxidized all the available materials (primarily ammonia and amino nitrogen compounds).

Breakpoint chlorinating can alter or break down the materials that contribute to taste and odour problems. Under carefully controlled conditions, it has the potential to improve operations at Elk Island.

There can be frequent and rapid change in the quality of raw water from Astotin Lake. Breakpoint chlorination is a delicate operation that is easily upset by dosage requirements. After taking into consideration the undesirability of excessive chlorine residual being distributed, breakpoint chlorination was not presented to the operators in more than a passing reference. Close operator attention is required at all times in this process. With a history of periods of low operator attention in this plant, it was felt that this process was not a viable alternative. However, if management at the Park has interest in this technique, additional information can be supplied.

7.3.5 Manganese Removal

High manganese in a water supply is an aesthetic concern, but not a health problem. There is no indication that manganese is causing a problem at Elk Island. levels of manganese present in Astotin Lake water occasionally can rise to a range where problems could occur.

A problem with manganese will manifest itself by leaving a black-coloured stain on household fixtures and in laundry. If this characteristic staining occurs in a persistent manner in the future, operation of the Administration Site water treatment plant will have to be altered to control the problem.

Methods of removing manganese are based on oxidation followed by filtration or sedimentation of the resulting precipitate. In practice, actual concentrations of oxidant and required retention times vary with the source water. Another important factor in manganese removal is water pH.

Common oxidants used in manganese treatment are chlorine, ozone, potassium permanganate and aeration.

Aeration for manganese reduction is generally not effective at pH below 9.5[ref.1]. Intense aeration for up to 60 minutes followed by clarification and filtration could be required to achieve

substantial reductions in manganese. Alum clarification decreased the pH of the water. Therefore, different coagulation chemicals would be required and they may affect the colour removal efficiency.

Chlorination of feed water to free chlorine levels of up to four milligrams per litre for 30 to 60 minutes, followed by filtration, is common on manganese removal. Long retention times and problems caused by the high chlorine (example THM formation) would discourage the use of chlorine in this case.

Ozonation is effective in oxidizing manganese. Additional benefits may be gained by locating ozonation equipment in the line before the clarifier, but this location may, or may not, require changes in coagulation chemicals (pH considerations). Location of an ozonation contactor between the clarifier and filter should be effective for manganese control. Careful design of a contactor in the pre-filter location could allow gravity flow to be used.

Aside from cost, two concerns, have to be considered before ozone is chosen. Overdosing with ozone would cause potassium permanganate to form, and a pink colour can develop in the product water. The second concern is with exposure limits to ozone. Occupational Health and Safety limits exist for exposure to ozone, but the safest policy is that any ozone odour is too much. Any installation of an ozone-addition system in a pre-filter location would have to control the ozone that would be released into the air from the contactor and the filter.

In the quantities required for use in the Elk Island situation, potassium permanganate would be the easiest and least expensive option. For optimum effect, potassium permanganate should have up to 10 minutes' retention time with the water controlled above pH 7.5. Injection of a permanganate solution into the overflow trough of the clarifier might provide enough contact time to be effective. The benefit of this oxidant would come after a manganese dioxide layer has formed on the filter sand. Thus, any trial should run for several days of operation. When using potassium permanganate, the pH of the product water should be controlled above pH 7.5.

Caution is advised when working with full strength potassium permanganate. The dosage should be carefully controlled, but an overdose is obvious by a pink colour in the water. No pink coloured water should be allowed to pass to the reservoir.

Other methods of manganese control include pressurized greensand filters, sequestering the manganese with polyphosphate, and lime treatment.

8 SUMMARY

During this contract period, the AEC and Elk Island staff contributed to experimentation, physical plant upgrades, process improvements and training of operators in an informal, co-operative relationship. The close co-operation helped overcome the difficulties of conducting this study at a time when both parties had other, ongoing commitments.

Some tasks required to complete this study took longer to complete than anticipated, including the final draft of this report. Some advantages were gained with the added time, including an opportunity to observe the priority given to operation of the Administration Site plant, and the resulting water quality, through a period when there was limited outside involvement.

8.1 Treated Water Quality

8.1.1 Colour

Concerns about colour in the treated water were foremost in the list of problems that were to be addressed in the work of the AEC at Elk Island.

The Astotin Lake supply contains high, and varying, amounts of apparent colour. Observed values ranged from 50 to 120 colour units in one year of observation. True colour varied less, but usually exceeded the guideline level set by Health and Welfare Canada[ref.2].

During this study, AEC technologists found that several processes were capable of reducing both apparent and true colour to guideline levels. The Administration Site water treatment plant, given proper attention and operated with controlled conditions and standard procedures, is capable of meeting the guidelines.

8.1.2 Chlorine

Control over chlorine addition was a major problem with the existing water plant at the time that this study was commissioned. The chlorine dosage at the time was not properly measured, recorded or controlled. Guideline levels for control were unknown to the operators. The level of chlorine in the product water was undoubtedly above acceptable levels.

Installation of a liquid chlorine system, purchase of more effective measuring equipment, and guidelines for the operators to work with, allowed for controlled conditions and production of a safer product.

The water plant is now capable of controlling chlorine and pH levels within ranges that are safe, and that should minimize chlorine-related odour complaints from the people being served by the plant. Occasional complaints may still occur, and should be investigated for merit. If complaints are received during periods when conditions are under control, the operators must resist the temptation to decrease chlorine levels since a safe residual must be maintained to the farthest point in the distribution system at all times.

Addition of chlorine to treated Astotin Lake water tends to produce odour in the product water. This is caused by the formation of compounds that may have lower odour detection thresholds than their unchlorinated precursors. This odour can be minimized by proper operation of the plant. Based on results from odour panels assembled for this study, it appears that none of the optional treatment processes examined in this study can completely avoid the offending odour at all times.

Other compounds formed when chlorine is added to this water include trihalomethanes. The long-term impact on health of trihalomethanes, and other similarly formed compounds, in drinking water is not fully understood. Responsible operation of drinking water facilities includes efforts to minimize the formation of these compounds.

Treatment for trihalomethanes is not usually practical after the addition of chlorine. Removal of the precursors to trihalomethane and other chlorinated compounds earlier in the treatment train is most effective.

8.1.3 Odour

Odour, as a problem in the Administration Site water plant product, has increased in importance as colour and chlorine problems were resolved.

Attempts to identify offending odours have tended to substantiate the general belief that taste and odour originate from algae and other aquatic growth in the source water. This type of organic broth typically has such diverse compounds present that identifying specific problem compounds is impractical. The solution to this type of problem is approached by generalized removal of organic matter, with appropriate methods determined by trial. The set of trials done

for this study suggest that some degree of related odour will likely remain in this water after any common treatment method.

Water presented to odour panels for this study was sampled from process trials treating Astotin Lake water during middle to late summer. Timing of these tests corresponded to what would likely have been some of the worst odour-causing conditions of the year.

Some experiments included observations of odour by AEC technologists or Elk Island operators. These tests were performed using a technique where the sample of water was warmed to 50°C in a closed container which was then opened and quickly checked for odour in the head space of the container. This test provided a conservative approach, allowing detection of odours that may have been missed, or were not present, at a cooler temperature.

Improvements in the operation of this plant have reduced the number and degree of odour (taste and odour) complaints about the product water. A slight musty odour is present in the chlorinated product of the Administration Site water plant when it is operated without upsets. When upsets in operation occur, odour in the water increases and takes on more of the less agreeable characteristics that were present before the improvements were made.

A return of taste and odour with chlorination appears to occur, in varying degrees, in all of the treatment processes investigated in this study. The highest degrees of treatment, such as ozonation and fresh carbon filter polishing of product water, produced odours that could only be detected in warmed samples.

While there is an odour problem in treated Astotin Lake water, the odour in question is substantially less objectionable than was the case before the plant improvements.

8.2 Physical Plant

The improvements made to the Administration Site water plant have greatly improved its operations thus far. Among the most important of these were: changes to the chlorine feed system; addition of new chemical feed equipment and re-location of the feed points; purchase of new monitoring equipment; installation of a rapid-mix chamber to the clarifier; upgrading the backwash system for the filter; and clarifier cleaning, including unplugging its inner works.

Steps that would further improve water quality, or would help prevent deterioration of the process by fouling, include: modification of the inner cone of the clarifier to prevent plugging; installation of a polymer feed system; clean-out of the distribution system reservoir; removal of

the cartridges that are currently installed in the residences; and installation of a carbon cartridge system inside the water plant (assuming the test system proves effective).

8.3 Operation of Existing Plant

The improvements made to the operation of the Administration Site plant to this point can be summarized by the following few points: (i) improved physical capability of the plant; (ii) development of operators through training and awareness of the process; (iii) initiating proper record keeping and monitoring practices.

In periods when attention has been given to the plant, and maintenance has had a high priority, the operators have proven that they are capable of smoothly operating the plant and producing high-quality water. Periods of decreased operator attention have resulted in upsets in water quality. The frequency of upsets has increased in the last year, and "normal" product quality has dropped.

Even if further improvements are made to the physical plant, treated water quality will continue to decline unless priority is given to plant operation and maintenance.

Clearly scheduled operator time has to be made available for production of suitable water. It is more important that regularly scheduled times be dedicated to the plant than to have large blocks of time allotted that do not have priority. The priority given to the plant and the product should be periodically reviewed to re-emphasize its importance.

Proper operation of the water treatment plant is currently possible under the care of the lead operator. The secondary operator has been provided with similar training time, but has not maintained constant exposure to the process, and is less well equipped to maintain high-quality operation without aid from the primary operator. A long-term absence of the lead operator would likely affect the quality of the product.

8.4 Options Available

Options for operation of a water treatment system on the Astotin Lake site include:

(i) Operation of the existing plant with an upgraded clarifier, polymer addition and clearly defined operator expectations. This is the least expensive option in terms of capital cost. The operators are trained in the operation, and the processes involved are relatively easy

to understand. The processes are also flexible enough to allow simple adjustments to changing conditions. Manpower requirements are relatively high.

(ii) Addition of carbon cartridge filtration to the plant as presented in (i) for reduction of odour and possible reduction of trihalomethane formation potential. The strength of this option is the simplicity of operation. The life of a cartridge has not yet been determined and may prove to be too short for economical operation.

(iii) Replacement of the existing system with ozonation and polymer-aided filtration, followed by chlorination. The product from this type of system would likely be comparable to that from the existing system during the worst raw-water conditions, and slightly better than the current system for much of the rest of the year. Operator time requirements are difficult to estimate, but would be similar to, and likely less than, the times outlined in this report for the existing system. The level of technical complexity facing the operator would be much higher than at the present time and errors in operation could result in high repair costs. The initial capital cost would be high.

(iv) Addition of pre-ozonation to option (i). Pre-ozonation may reduce the potential for trihalomethane formation. Field trial results suggest that pre-ozonation before clarification helps to optimize operating conditions in the plant, and so provides a more consistently high quality water. Since the same trials suggest that the plant is capable of producing water of similar quality if suitable attention is given to its operation, the high capital cost and operational complexity would make this option unreasonable.

(v) Exploration of slow sand filtration for possible long-term implementation. Not enough information is currently available to judge the merits of this technology in application to Elk Island. If further study were to show it to be worthwhile, an installation within the existing building might be possible. This option has been included since it has the potential to provide suitable water quality with the lowest operator time requirements (and complexity) of any of the options considered. The AEC is considering an investigation of slow sand filtration as a treatment for problems similar to those at Elk Island and would be willing to pass along information as it becomes available.

(vi) An installation using pressure filtration followed by microfiltration (five micron pore size or less), similar to that recently established at the Campground Site water treatment plant on Astotin Lake. This type of plant is one of the lowest maintenance options available.

If problems with premature fouling of the microfilters could be avoided (by using a progression of pre-filters), this type of plant would be effective in reducing apparent colour. This type of plant likely would not be effective in reducing true colour below guideline levels, and would not be expected to reduce taste or odour below what is present in the lake. Addition of granular activated carbon filters in a pressure system might alleviate these problems, but the effective life of the carbon would be short, and frequent replacement of carbon would be expected.

None of the options available lend themselves to fully automated operation. Water quality would suffer if neglected in any operation.

8.5 Conclusions

We believe that the current water treatment plant (operated as outlined in option (ii) in Section 8.4) would be the best choice for a balance of budget and water-quality concerns.

An optimized Administration Site water treatment plant is capable of providing acceptable-quality water. Addition of a carbon cartridge system to the plant may reduce residual odour problems as well as trihalomethane production after chlorination.

Maintaining the quality of product from this plant over the long term cannot be left solely to the judgment of the operators. Conflicting demands on operator time and lack of interest in routine operation, at all levels, will lead to erosion of time and effort spent in the plant.

Appointment of a person, aside from an immediate manager or co-worker, to a water quality review role may help to prevent erosion in the priority given to the plant. The main objective of the person in this role would be to maintain the priority of the water plant. To be most effective this review should be conducted with a non-confrontational approach, and with some degree of influence backing it.

Building consumer confidence in the product being pumped to households will take time. A supply of consistently high-grade water is required. If a relatively taste-free water with carefully controlled chlorine levels is available, the convenience of using the tap will ultimately reduce the amount of water being hauled to the Park. Use of the office distiller would also decline over time.

The Administration Site water plant can supply safe water with a slight taste problem. This level is comparable to water supplied to several Alberta communities, and less severe than

that distributed in many others. As a result of experiences that the consumers have had with this water system, it is likely that each upset in operation would cause a disproportionate setback in confidence. The priority given to this plant will have a major impact on the frequency of upsets.

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10 APPENDICES

EVALUATION OF DRINKING WATER PLANT AT ELK ISLAND NATIONAL PARK ASTOTIN LAKE ADMINISTRATION SITE

September 15, 1991

10.1 Correspondence

10.1.1 Preliminary Information

#530, 220 - 4th Avenue S.E.
P.O. Box 2989, Station "M"
Calgary, Alberta, T2P 3H8

January 21, 1988

File #C2945/E2

Dr. Albert Van Roodselaar
Head, Operations
Alberta Environmental Centre
Bag 4000
Vegreville, Alberta
T0B 4L0

Dear Dr. Van Roodselaar:

Re: Elk Island Water Supply

Further to our telephone conversation of today's date, enclosed are copies of the chemical analysis and a description of the water system in Elk Island.

We wish to thank you and accept your offer to perform further testing of the water in Elk Island and to provide your recommendation as to the best method of dealing with the high organic concentration in the water.

This was discussed with Mr. Dave Pick, Superintendent, Elk Island National Park, and he will be contacting you concerning the testing, etc. The Park staff were also very interested to learn that ozone is being used to treat the water at the Ukrainian Centre and they will be checking on the quality of the water (i.e., taste and odor) over the summer months.

2

After you have had an opportunity to carry out the initial testing we would like to have a meeting with you and the Park staff at a location convenient to you to determine the next step.

If you have any questions please phone me collect.

Yours truly,

Rae Howe

R. Howe
Coordinator
Engineering & Works
Architectural and
Engineering Services
Environment Canada,
Western Region

Attach./ms
Howe/hk
c.c.: Superintendent,
Elk Island N.P.

4. EXISTING UTILIZED WATER SOURCES*

Astotin Lake is utilized to provide 89% of the water withdrawn for human consumption and domestic use in Elk Island National Park. The Astotin Lake campground plant provides 26% and the Astotin Lake Administration Headquarters plants provides 63% (see Chapter 3). Eight individual groundwater sources provide the remaining 11% of water for human consumption and domestic use.

4.1 Astotin Lake Campground Plant (L1)

The Astotin Lake campground plant was built in 1961 and has been operated on a seasonal basis (May through September) ever since. In 1986, the plant consists of:

- a gravity flow pipe intake into the lake
- a raw water sump in the plant building, connected to the intake
- a cascade aerator
- a microstrainer
- a gas chlorinator
- a clear water sump
- a hydropneumatic storage tank

* The symbols after each water source refer to its location on the map (Figure 4.1 Locations of Water Sources in Elk Island National Park).

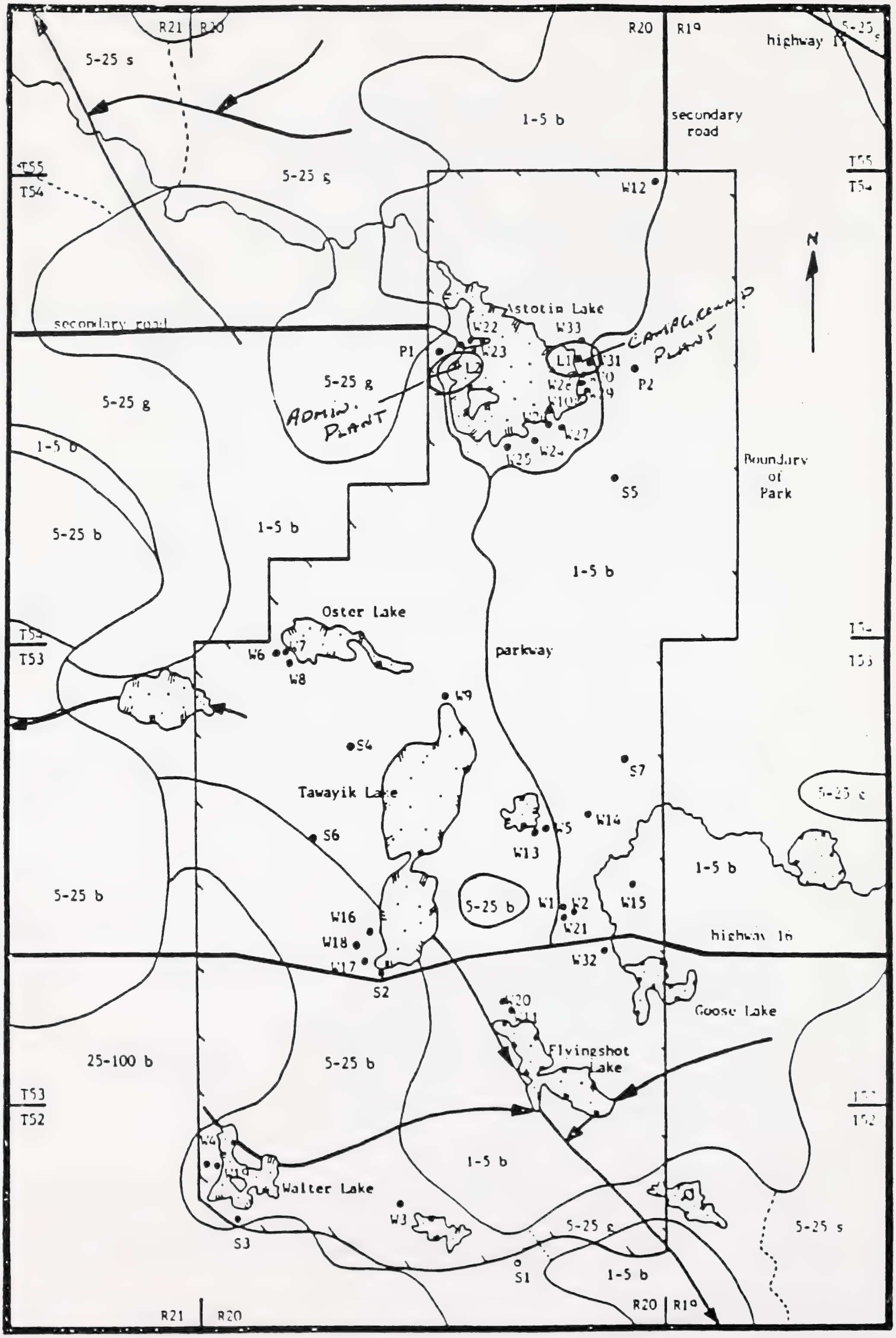


Figure 4.1 Locations of Water Sources in Elk Island National Park (source: Stein, 1976).

FIGURE 4.1

Key to Map

W	well
S	spring
L	lake intake/plant
P	sewage lagoon
1-5 b	yield 1-5 ig/minute in bedrock
5-25 b	yield 5-25 ig/minute in bedrock
25-100 b	yield 25-100 ig/minute in bedrock
5-25 s	yield 5-25 ig/minute in sand
5-25 g	yield 5-25 ig/minute in gravel
T	township
R	range
	thalweg of buried preglacial channel
	Park boundary

Originally, the plant was constructed without the cascade aerator, which was added in 1963. A diatomaceous earth vacuum filter was part of the original plant equipment, but was disconnected in 1968 and is still unused. A water meter was installed sometime after the plant was in operation and removed in 1969. Design specifications and operating records indicate that the plant capacity is 50 ig/minute (227 L/minute).

The galvanized steel gravity flow intake pipe is 250 mm in diameter and extends 40 m into the lake. The intake inlet is approximately 2.1 m below water level and approximately 0.3 m above the lake bed. The inlet is equipped with a grate screen with 40 mm slots. The concrete raw water sump is 1,050 mm in diameter and approximately 6.7 m deep.

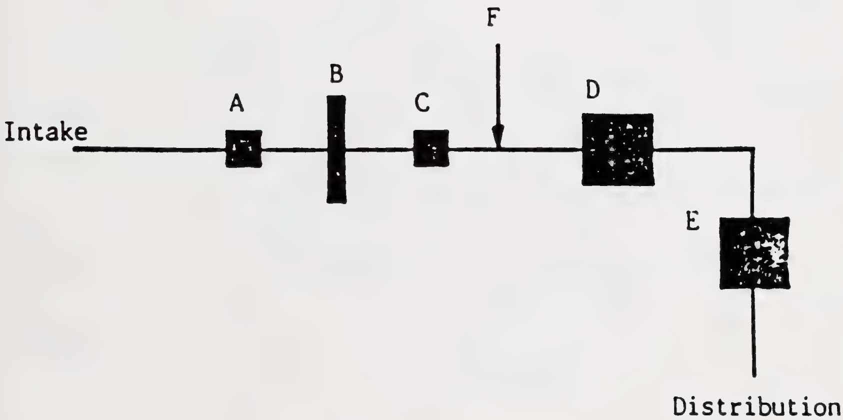
A cascade aerator was added in 1963. Water is pumped from the raw water sump to the top of the approximately 2.5 m high aerator, and allowed to cascade over a series of baffle plates, and discharge into a small concrete storage chamber.

Water is pressurized through the rotating microstrainer screen, which is intended to be self-cleaning. Particulate organic matter can plug the microstrainer however, and flow from the microstrainer and, hence plant capacity, has been restricted in the past; 30 ig/minute (136 L/minute) in 1964 & 1967. In 1967, the microstrainer was bypassed and remained inoperative until 1968, when it was re-connected. During the time that the microstrainer was bypassed, a cyclone separator was installed on a trial basis, but failed to significantly reduce the particulate organic matter content of the water.

The gas chlorination system originally installed is still in operation. The chlorine gas feed rate is controlled by adjustment of a

Figure 4.2

Astotin Lake Campground Plant 1986 (schematic)



A	Raw water sump
B	Cascade aerator
C	Microstrainer
D	Clear water sump
E	Hydropneumatic tank
F	Gas chlorination

chlorine control valve, in response to variations in water line pressure.

The diatomaceous earth vacuum filters were subject to frequent plugging. Frequent filter backwashing, and resultant media loss, resulted in the consumption of approximately 7 pounds (3.2 kg) of diatomaceous earth for every 1,000 ig (4.5 m^3) of treated water produced in 1967. Several types and grades of diatomaceous earth media were tried in the filter, including precoated media, without successfully improving filter operation. The filter was bypassed in 1968 and remains unused.

A clear water well located after the diatomaceous earth filter collects treated water, which is then pumped into a 22,000 ig (100 m^3) steel hydropneumatic tank. Water is supplied under an average of 50 psi (350 kPa) to the campground area distribution system.

Chemical water analysis reports are available for raw and treated water from the plant, from 1961 until the present. Little variation is evident in the overall chemical quality of the raw lake water during this period (see Table 4.2). The 1986 chemical water analyses (see appendix 1.1 and 1.2) indicate that the raw and treated plant water meets or exceeds the Guidelines for Canadian Drinking water Quality 1978 (Health and Welfare Canada, 1979). A maximum acceptable level for hardness has not been established, since public acceptance of hardness varies considerably; however, it is suggested that hardness in excess of 200 mg/L is considered undesirable. The hardness of the raw lake water, primarily calcium and magnesium bicarbonate, is slightly above the level considered desireable.

TABLE 4.1

MAXIMUM ACCEPTABLE & RECOMMENDED CONCENTRATIONS FOR CHEMICAL AND PHYSICAL WATER ANALYSES

Parameter	*Maximum Acceptable Concentration	* Objective Concentration	** Recommended Limit
Total Dissolved Solids	500	-	1,000
Hardness	-	-	200
Alkalinity	-	-	500
Sulphate	500	<150	500
Chloride	250	<250	500
Nitrate (as N)	10	<0.001	10
Nitrite (as N)	1.0	<0.001	1.0
Sodium	-	-	20
Bicarbonate	-	-	-
Iron	0.3	<0.05	0.3
Fluoride	1.5	1.0	1.5
Calcium	-	-	75
Magnesium	-	-	500
Potassium	-	-	-
Carbonate	-	-	-
pH	6.5-8.5	-	8.5
Color (TCU)	15	<15	-
Taste	-	inoffensive	-
Odor	-	inoffensive	-

*Health & Welfare Canada, 1979.
**Leduc-Strathcona Health Unit, 1984
All values in mg/L except as noted.

TABLE 4.2

SELECTED CHEMICAL ANALYSES
ASTOTIN LAKE CAMPGROUND PLANT

	1961		1964		1986	
	R	T	R	T	R	T
Total Dissolved Solids	448	451	360	682	451	317
Hardness	263	265	230	245	240	145
Alkalinity	142	144	222	235	200	165
Sulphate	180	177	23	202	88	34
Chloride	3	4	0	10	4	2
Nitrate & Nitrite N	0.1	0.1	0	<0.1	0.2	<0.1

R = Raw water

T = Treated water

Values expressed as mg/L

Values rounded

Source: Parks Canada; Author

Bacteriological water analysis reports are also available for the 1961 to 1986 period. The analyses consistently show no evidence of bacteriological contamination, as indicated by the absence of both total coliform and fecal coliform bacteria. The general bacterial population, as indicated by frequent standard plate counts in excess of 3,000/ml, is evidence of high concentrations of micro-organisms in the raw and treated water, which is common in surface water supplies. Adequate chlorine residuals in the distribution system are required to prevent bacterial growth, when standard plate counts exceed 500/ml (Health & Welfare Canada, 1979).

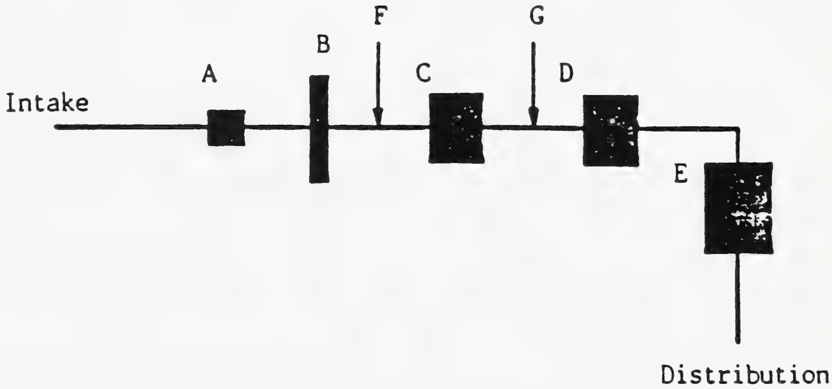
Physical water quality is not well quantified, but objectionable tastes, odors and color are the main reasons for complaints about water quality from the plant. The water is high in particulate organic matter, primarily decomposing algae and aquatic vegetation. The prevalent description of the water's taste and odor is "swampy or organic." The water color is light yellow, typically ranging from 50-200 true color units, which exceeds the recommended limit of 15. Occasional complaints of an objectionable chlorine taste and odor are caused by variations in the free chlorine residual. Records at the plant for 1986 indicated a free chlorine residual range of 0.1 - 2.0 mg/L so far that year.

4.2 Astotin Lake Administration Headquarters Plant (L2)

The Astotin Lake administration headquarters plant was built in 1963 and has been operated on a year-round basis ever since. The plant has not been modified since construction, and consists of:

Figure 4.3

Astotin Lake Administration Headquarters Plant 1986
(schematic)



A	Raw water sump
B	Cascade aerator
C	Coagulant/flocculation chambers
D	Gravity sand filter
E	Hydropneumatic tank
F	Gas pre-chlorination
G	Gas post-chlorination

- a gravity flow pipe intake into the lake
- a raw water sump in the plant building, connected to the intake
- a cascade aerator
- gas prechlorination
- coagulation and flocculation with aluminum sulphate, with sodium carbonate buffering
- gas postchlorination
- a gravity sand filter
- a hydropneumatic storage tank

Design specifications and operating records indicate that the plant capacity is 50 ig/minute (227 L/minute).

The galvanized steel gravity flow intake pipe is 100 mm in diameter and extends approximately 15 m into the lake. The intake inlet depth below water level is not recorded, but is assumed to be less than approximately 2 m, since the receiving raw water sump bottom is approximately 2 m below lake water level. This should be confirmed by measurement when conditions permit. The concrete raw water sump is rectangular, 900 mm x 1,200 mm x 3,000 mm deep.

Water is pumped from the raw water sump into the elevated cascade aerator, which is approximately 1,000 mm high, and allowed to cascade over a series of baffle plates. Compressed air is introduced concurrent to the water flow by a blower. The water is then prechlorinated with a gas chlorinator, and then flows into a contact chamber. The contact chamber is 1,730 ig (7.9 m^3) capacity.

Aluminum sulphate is fed as a solution into the contact chamber with a positive displacement feeder pump. The feed ratio for the

aluminum sulphate solution is approximately 1,000:1 by volume. After detention and mixing in the contact chamber, the water passes into a settling chamber and is post chlorinated with a gas chlorinator. Sodium carbonate is fed as a solution into the settling chamber effluent, prior to filtration, to raise pH back to a neutral range.

In 1966, several other combinations of water treatment were evaluated. A coagulant aid, activated silica, was fed in addition to the aluminum sulphate, in an attempt to improve treated water quality. Also, activated carbon was fed by a volumetric solids feeder into the contact chamber for taste and odor control. Potassium permanganate solution was evaluated for taste, odor and color removal. The three trial evaluations in 1966 did not significantly improve treated water quality, and were discontinued.

The gravity sand filter is 1,050 mm in diameter and contains an approximately 1,070 mm deep filter bed, composed of graded sand with a gravel support bed. The flow rate through the bed is approximately 5 ig/ft^2 (244 L/m^2). Backwash flow rate available is 90 ig/minute (409 L/minute).

Water from the gravity sand filter is collected in a clear water sump, then pumped into a 330 ig (1.5 m^3) steel hydropneumatic tank. Water is supplied under pressure at approximately 55 pounds/square inch (385 kPa) to the administration headquarters distribution system.

TABLE 4.3

SELECTED CHEMICAL ANALYSES
ASTOTIN LAKE ADMINISTRATION HEADQUARTERS PLANT

	1963		1964	1966	1986	
	R	T	T	T	R	T
Total Dissolved Solids	NV	NV	209	380	303	294
Hardness	202	[illegible]2	184	230	135	135
Alkalinity	202	288	190	195	160	145
Sulphate	NV	NV	38	51	29	27
Chloride	NV	NV	3	5	2	14
Nitrate & Nitrite N	NV	NV	<0.01	0	0.8	0.1

R = Raw Water

T = Treated Water

NV = No value reported

Values expressed as mg/L

Values rounded

Source: Parks Canada and Author

Chemical water analysis reports are available for the raw and treated water from the plant, from 1963 until the present. Most chemical analyses on file are for the treated water. During 1965, the water treatment plant operator kept weekly records of the raw and treated water hardness and alkalinity (calcium carbonate equivalent). Little

variation is evident in the overall chemical quality of the raw and treated water during the time the plant has been in operation (see table 4.3). The 1986 chemical water analyses (see appendix 1.3 and 1.4) indicate that the raw and treated plant water meets or exceeds the Guidelines for Canadian Drinking Water Quality 1978 (Health & Welfare Canada, 1979, Leduc-Strathcona Health Unit 1984). Although hardness has exceeded the desireable level of 200 mg/L in the past, it is in 1986 at an acceptable level.

Bacteriological water analysis reports are also available for the 1963 to 1986 period. The analyses consistently shows no evidence of contamination, as indicated by the absence of both total coliform and fecal coliform bacteria. The general bacterial population in the treated water is low, as indicated by frequent standard plate counts of 100/ml or less.

Physical water quality is well quantified. Objectionable tastes, odors and color are the main reasons for complaints about the water quality from the plant. The water is high in particulate organic matter, primarily decomposing algae and aquatic vegetation. The water has an "organic or swampy" taste and odor. The water color is light yellow, typically ranging from 50-250 true color units, which exceeds the recommended limit of 15. Objectionable chlorine tastes and odors are not common; records at the plant for 1986 indicated a free chlorine residual range of 0.1 - 0.3 mg/L so far that year.

Evaluation and discussion of the Astotin Lake Plants is contained in Chapter 9.

- Roads:

  - Gravel access roads all around the Administration Area as shown on Map 4.

2.2.3 WATER_TREATMENT_PLANT

- Plant located in the east end of the administration area.
- Plant constructed in 1962.
- Draws water from Lake Astotin.
- Intake from the lake at unknown distance from shore and approximately 1.2 metres below the normal lake surface. Screen information not known.
- Raw water intake pump capacity, 1.1 L/s, Robins Meyers model EC560, progressing cavity pump, belt driven.
- Raw water meter Fisher and Porter Precison, Model # B9-27-10/77, rated 2.27 l/s.
- Aerator with Chicago blower, details unknown.
- Chemical System.
  - alum mixer, Lightnin, type ST, .19 kw, 60HZ, 1725 rpm, 115 volts
  - soda ash mixer, Lightin, .19 kw, 115 volts, 60HZ, 1725 rpm
  - two chemical feed pumps, Prominate Fluid Controls Ltd. with 2 chemical storage tanks
  - wood stave alum tank
  - soda ash in metal tank
- 2 service pumps, Ramoy Heleco progressing cavity pump, model # 35601 and Doerr Farm Duty 1740 rpm, 1.12 kw, 115 volts, 18 amp motor.
- Service pump controls control pressure setting at 365 kPa and 380 kPa.
- 1 m diameter by 2.4 metres high pressure tank with sight glass.
- Pressure tank air charger, air compressor DevilViss Canada Ltd., Type UCAJ-5001/0-223, 0.38 kw motor, rated at 845 kPa at 1220 rpm and 1034 kPa at 900 rpm.
- Treatment unit combination of contact chamber and gravity filter.
- Contact chamber, Cochrane Reactor (Cochrane Water Conditioning Ltd.), Serial # 603343, maximum rating 68 litres, 1.3 l/s, 0.38 kw motor, 1725 rpm, Lealand Electric Canada Ltd., Contact chamber 3.05 metres high and 2.03 metres in diameter.

- o Gravity filter 1.06 metres diameter by 3.03 metres high.
- o Carbon Feeder in chlorine room, BIF model #50A, not operational.
- o Backwash pump for sand filter Fairbanks Morris Model # 1.55551D, 1.13 kw, 3450 rpm.
- o Hach residuel chlorine test kit.
- o Building size 6.1 m by 6.1 m of concrete block construction with 6.1 m by 6.1 m wood frame addition to north side.
- o Building heated by 2 natural gas units, unit heaters suppended from the ceiling, one is original building and one is addition.
- o Electrical control and motor control panel.
- o Plant maintaining reasonable condition, equipment aging but generally in good working condition.

o Plant Defeciencies:

- o Raw water pump and treatment system inadequate to supply hot weather and high demands.
- o Automatic backwash on the gravity filter diconnected.
- o Treatment unit 25 years old, replacement parts for maintenance not available.
- o No operations and maintenance mannual.
- o No as-built drawings for the entire plant.
- o Some of the pumps and pipes coroding.
- o Distribution Pumps operate on short cycles against normal ten minute pump cycle times.
- o Electrical control panel not visible from door.
- o Chlorine room access through treatment plant.

2.2.4 SANITARY SEWAGE COLLECTION AND TREATMENT SYSTEM

Piped sewage sewage collection for administration area consists of 150 mm diameter asbestos cement pipe sewers, a sewage lift station, 100 mm diameter cast iron forcemain, and sewage lagoon.

o Sewers:

- o 150 mm diameter aspestos cement pipes of total length 1130 m.
- o Buried depth 3.5 m approximately
- o No operational problems identified.

10.1.2 Suggested Terms of Reference

Public Works Canada
Architectural and Engineering Services
Environment Canada Western Region

Travaux publics Canada
Services d'architecture et de génie
Environnement Canada Région de l'Ouest

#530, 220 4th Avenue S.E.
P.O. Box 2989, Station "M"
Calgary, Alberta, T2P 3H8

May 4, 1988

Dr. Albert Van Roodselaar
Head, Operations
Alberta Environment Centre
Bay 4000
Vegreville, Alberta
T0B 4L0

Dear Sir:

Re: Elk Island Water Supply
Pilot Study

Further to our meeting last Thursday, attached are our suggested Terms of Reference. Please consider these as suggestions for consideration and discussion. We feel the Terms of Reference will only provide a general direction for the pilot study. As a spin-off benefit of the study we would like to improve the operation of the present plant.

I had hoped to get this to you sooner. As discussed at our meeting we will have to obtain funding approval for any study. Our next Budget Meeting is Wednesday, May 18, 1988, which doesn't leave much time. We would appreciate receiving, at your earliest convenience, your proposed cost sharing formula for the study.

Yours truly,

Rae Howe

Rae Howe
Coordinator
Capital & Works Division

Howe/hk
Attach.

Canada

TERMS OF REFERENCE

PILOT WATER PLANT STUDY

ELK ISLAND NATIONAL PARK

BACKGROUND

The water supply serving the major facilities in Elk Island National Park is treated water from Astotin Lake. The water generally meets the required bacteriological and chemical criteria for drinking water but it has a taste and odor problem. The local Park employees generally haul their drinking water from the Regional Water District.

The objective is to provide a water supply of similar quality to the Regional water to eliminate the need to haul water and provide an acceptable quality for both public and private use. This could be provided in a number of ways but as a satisfactory ground water source is not available, it appears the best economic course would be to improve the treatment of the lake water.

As pointed out by Alberta Environment at our meeting of April 28, 1988, the quality of the treated water is a factor of not only the treatment method and equipment but of all operation and maintenance procedures. Therefore, the pilot study should also address these other factors where they can be tied into the pilot study.

SCOPE

The scope of the study and the results should include:

1) Monitoring of the seasonal variation in the quality of the raw water supply. This should also consider whether there is any difference in quality at different depths of water or locations in the lake in the vicinity of the present intake.

2) Determine the major source of the taste and odor problem, i.e., is it in the raw water, treatment process or a combination of these.

3) To test under field conditions the result of ozonation, coagulation, filtration in varying combinations to determine the optimum process.

4) To carry out a user survey to determine whether the optimum treatment process will produce a satisfactory water quality.

5) Monitor the operation of the plant to determine:

(a) Whether the plant can be adapted to the proposed treatment process.

(b) Should the present plant operation be changed to improve the treatment. This may look at such things as:

- rate of production;
- continuous versus intermittent operation;
- start-up procedures; how long does it take the plant to stabilize and should the initial flow through the plant be wasted.

If the pilot test proved positive we would like to receive basic design information which would enable us to proceed with the design. This should include:

(a) New processes to be incorporated into the plant.

(b) Recommended changes to the existing plant including performance specifications for the equipment. This could include controls, testing equipment, etc.

(c) Recommended operating instructions for the plant, keeping in mind the plant is operated by the Park on a part-time basis.

SUMMARY

If the present lake water cannot be upgraded to a satisfactory standard then other options which could be considered are:

(a) Treating of the highly mineralized ground water.

(b) Connection into the Regional Water Soruce.

(c) A dual water system with hauling or additional treatment of lake water. In any event, any tap water should be of potable quality in the event of its possible consumption.

These options could affect decisions made during the pilot study.

10.1.3 Suggested Report Breakdown

Public Works Canada
Architectural and Engineering Services
Environment Canada Western Region

Travaux publics Canada
Services d'architecture et de génie
Environnement Canada Région de l'Ouest

Rm. 530, 220 - 4th Ave. S.E.
P.O. Box 2989, Postal Stn. M
Calgary, Alberta, T2P 3H8

October 11, 1988

Alberta Environment Centre
Bag 4000
Vegreville, Alberta
T0B 4L0

Attention: Mr. Brian Gray, P.Eng.

Dear Mr. Gray:

Re: Pilot Water Testing -
Elk Island National Park

Further to our meeting last Monday, I would like to suggest the following breakdown for your report.

The objective for the water treatment is to produce water meeting the drinking water standards and of a quality where the water would be used by the local residents. Therefore, I would suggest that your reports be divided into two divisions.

a) Improvements to the plant and its level of operation to produce a suitable water.

b) Extra treatment "ozonation, etc." that could be added to further enhance the plant.

Besides listing the improvements to the plant it would be appreciated if you could enlarge on it by listing the type of equipment you have found to give satisfactory performance. Also if there is any special consideration such as:

- you mentioned that valves on the alum feed should be plug valves and not gate valves;
- the slurry feed tanks should have sight glasses with a valve so the valve can be closed and the feed rate measured by the rate of drop in the sight glass.

We would appreciate receiving this type of information.

With regard to the plant operation, could you provide a description of the tests and the types of things the operator would have to observe and do in order for the plant to be operated satisfactorily.

I trust this will clarify our objectives and if you have any concerns or questions, please give me a call.

Yours truly,

Rae Howe

Rae Howe, P.Eng.
Coordinator,
Engineering Works Division
Architectural & Engineering
Services - Western Region

Howe/hk

10.2 Preliminary Study

A PRELIMINARY STUDY

OF

COLOR REMOVAL

FROM

ASTOTIN LAKE WATER

IN

ELK ISLAND NATIONAL PARK

Preliminary studies on the treatment of water from Astotin Lake in Elk Island National Park for potable use were done at the Alberta Environmental Centre during February and March of 1988. Samples for these tests were drawn from the feed water line at the park's administrative water treatment plant on February 11, 1988 and March 24, 1988.

The primary objective in these studies was the removal of color from the water. Other parameters measured are within water quality guidelines with the possible exception of phenols.

Results of the tests have shown effectiveness for 4 treatment processes, to be used separately or together. These processes are alum coagulation, ozonation, conventional filtration with filter aid, and activated carbon filtration.

To make further recommendations the processes would have to be tested under field conditions. The water quality should also be monitored through yearly cycles to ensure its basic characteristics do not change. In order to accomplish these objectives the following schedule is proposed:

1. Two months of field work at Astotin Lake evaluating ozonation, alum coagulation, and filtration using pilot scale equipment.
2. Two weeks of preliminary bench scale work to optimize the field work.
3. Two to three weeks per year of ongoing sampling and bench scale tests to determine a seasonal profile of water characteristics.

INTERPRETATION OF RESULTS

The ozonation results show a typical dose response curve with less color removal per unit dose of ozone at higher doses. An optimal dose of 20 mg/L is indicated from the graph although further tests would be required to confirm this under field conditions. The difference between apparent[2] and actual[1] color is suspected to be particulate matter which could be removed by filtration.

Activated carbon filtration shows a very good removal of actual[1] and apparent[2] color. The brief reduction of color below the detection limit after the introduction of Poly Aluminium Chloride indicates a further study into evaluating filter aids.

Alum flocculation tests show a good removal of actual[1] color with some success of removing apparent[2] color at higher alum doses. These results in conjunction with the carbon filtration results indicate that field tests with optimized coagulation and flocculation followed by filtration could show an effective water treatment process.

Within the scope of this paper water color is determined by the following measurements.

1. Actual Color

   Actual color refers to the color of a sample, after filtration through a 0.8 μm nylon membrane, with no pH adjustment to the sample. The absorbance of the samples is measured using a colorimeter at 465 nm* and this value is then compared to a series of platinum cobalt standards. The concentration, using Beers Law, is then determined and reported in color units (C.U.)

2. Apparent Color

   The apparent color is determined on the original water sample without filtration or pH adjustment. The absorbance is read on a colorimeter at a wavelength of 465 nm*. The absorbance value is compared to a series of platinum cobalt standards and the concentration, using Beers Law, is then determined and reported in color units (C.U).

* A Brinkmann dipping probe colorimeter, model PC 800, was used for the color determinations. The wavelength used was 470 nm, because there is no filter for 465 nm with this unit.

APPENDIX A

RESULTS

Samples for testing were taken from Astotin Lake on February 11, 1988 and March 24,. 1988. The Process Control Laboratory tested the water when it was sampled and assessed the apparent[2] color at 80 to 90 C.U. and the actual[1] color at 13 to 16 C.U. Tests were then done on these samples in the treatment areas of flocculation, ozonation, conventional filtration and carbon filtration.

The first set of tests were done on the February 11 sample. These consisted of tests for flocculation using alum and the flocculant aids soda ash ($NaCO_3$) and lime ($CaCO_3$). Later, on the March 24 sample, poly aluminium chloride was tested in a similar trial.

Alum: Dosage levels between 10 and 130 mg/L were tested. In these tests actual[1] color was reduced to 1 C.U. at a dosage of 100 mg/L but apparent[2] colour changed only by the 6 C.U.

Alum/$NaCO_3$: Since these are the chemicals currently in use at the Elk Island Treatment Plant dosages were chosen to fall into the range of that plants operation. Dosage rates chosen for alum were between 400 and 500 mg/L. $NaCO_3$ dosage remained at 240 mg/L for all the tests.

Actual[1] color removal was similar to tests with just alum (down to 2 C.U.). Apparent[2] color removal was significantly better than in the previous test with a level of 40 C.U. at 440 mg/L Alum, 40% reduction.

The Alum vs Alum/$NACO_3$ graph suggests that the better removal here is related to the higher alum dose and further tests are needed to study the effects of soda ash.

Alum/$CaCO_3$: Trials using $CaCO_3$ as a flocculation aid at concentrations of 100 mg/L and alum between 10 and 130 mg/L does not significantly improve the color removal effectiveness of the alum.

Poly Aluminium Chloride: Flocculation Trials done with poly aluminium chloride did not show a significant reduction of actual[1] or apparent[2] colors.

Poly Aluminium Chloride was also added mid point into a carbon filtration test. Graphing the results of that test shows that there was an immediate, but short lived, reduction in the apparent[2] color below the detection limit of 5 C.U. (Brinkman color meter).

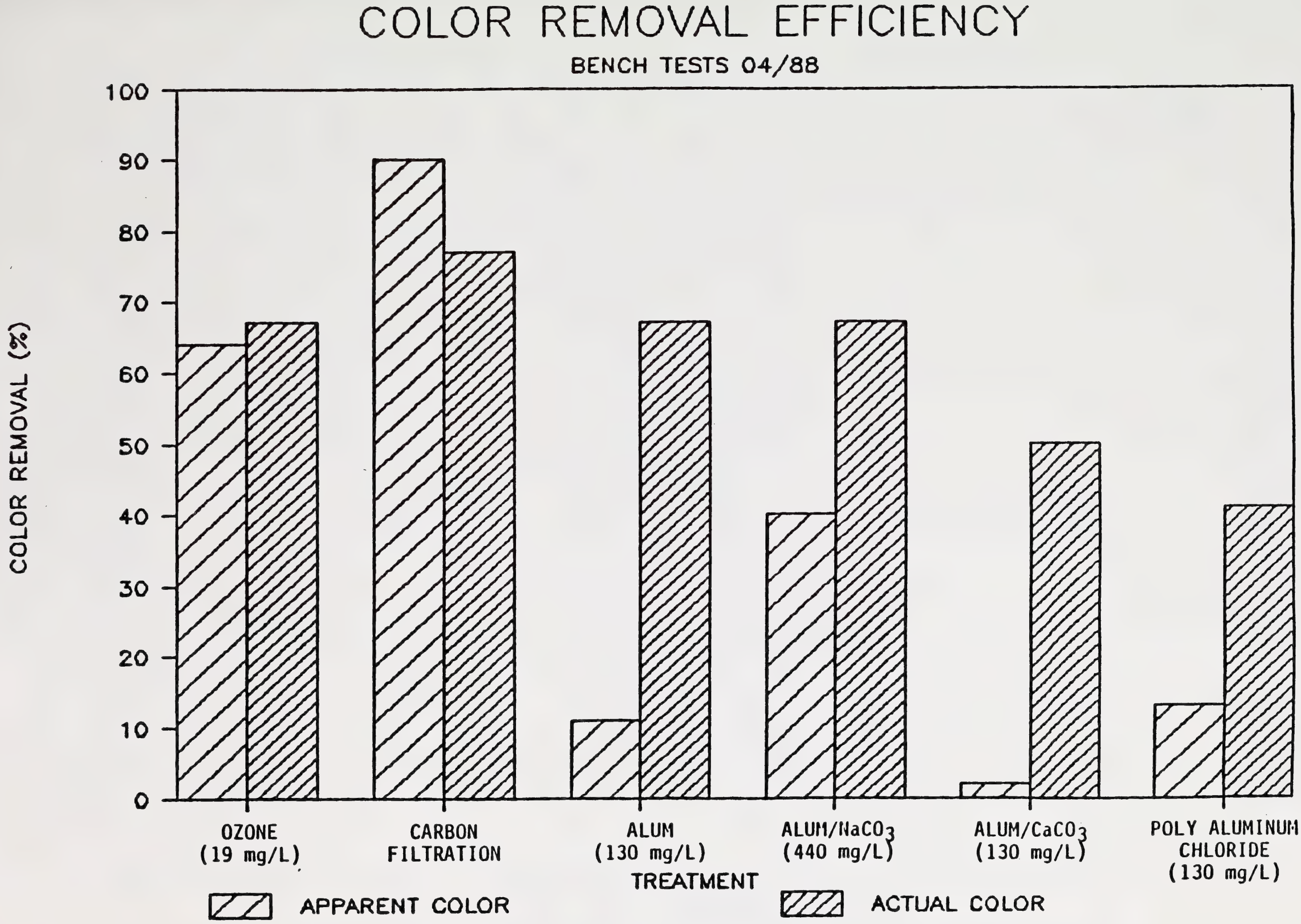
Carbon Filtration: Carbon filtration was very effective in removal of both actual[1] and apparent[2] color. Removal rates were >77% for actual and 90% for apparent for trial levels of <5 C.U. actual[1] and 8 C.U. apparent[2].

Ozone: Ozone was bubbled through a glass column with the sample water with it. Analysis was done on samples drawn at different time through the test and those times were used to calculate the dosage of ozone. The actual[1] was reduced 67% to 5 C.U. and apparent[2] color dropped 65% to 29 C.U.

BG/bad
1023C
2440-CS9
88.04.22

APPENDIX B

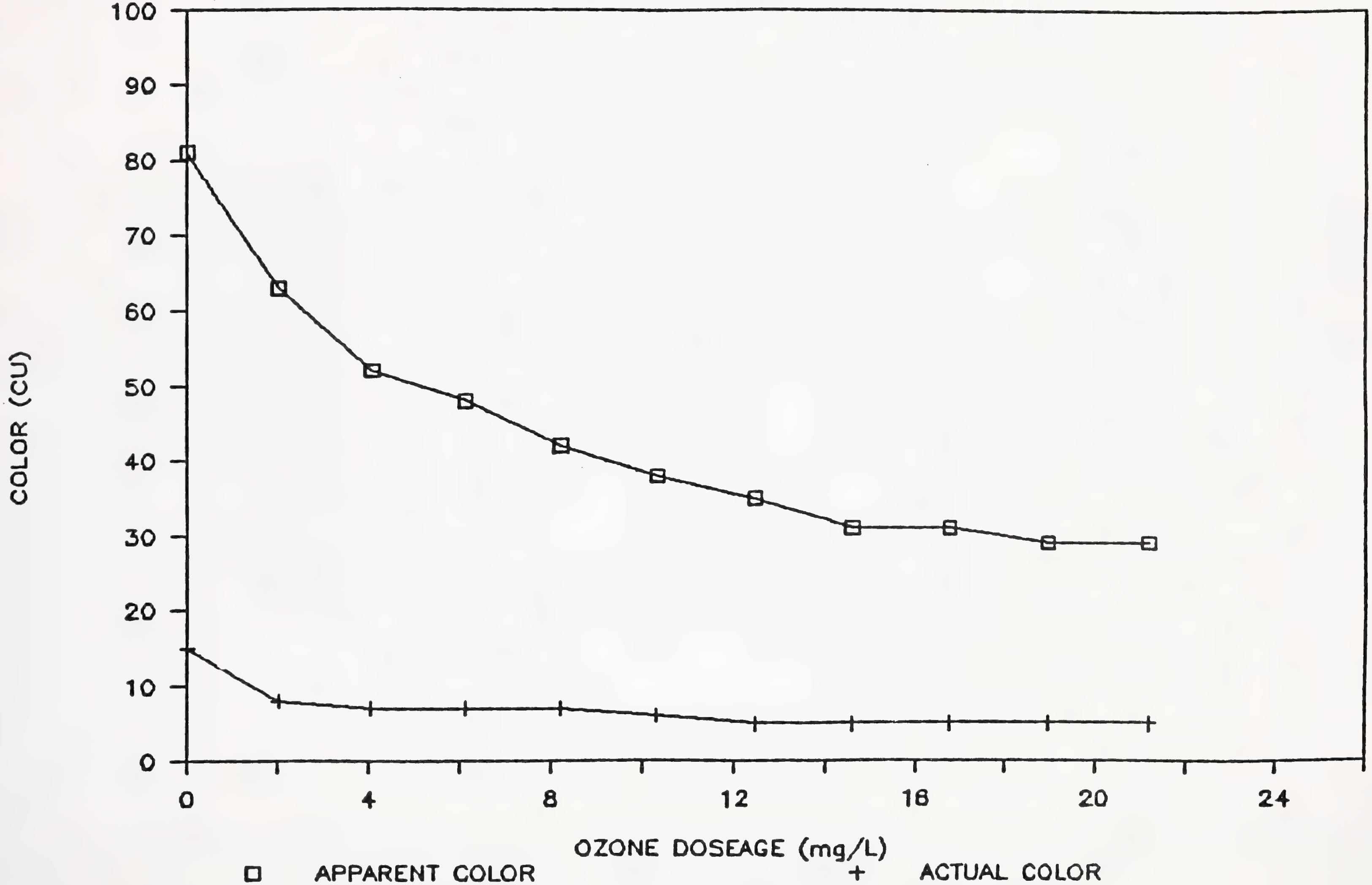
GRAPHS

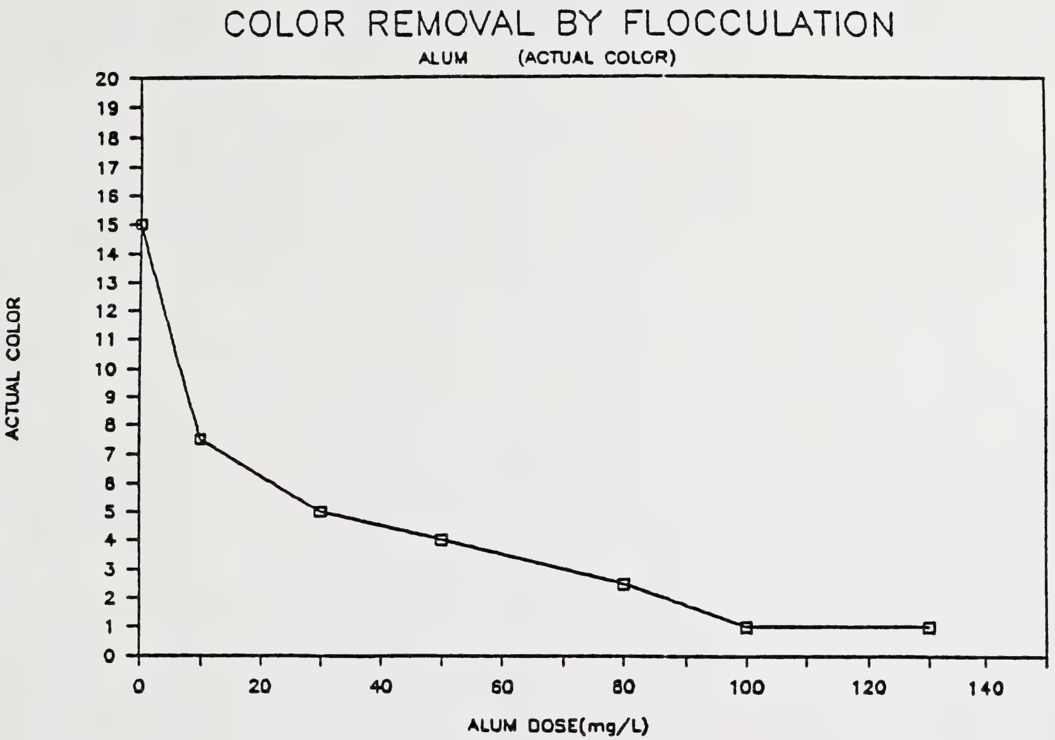


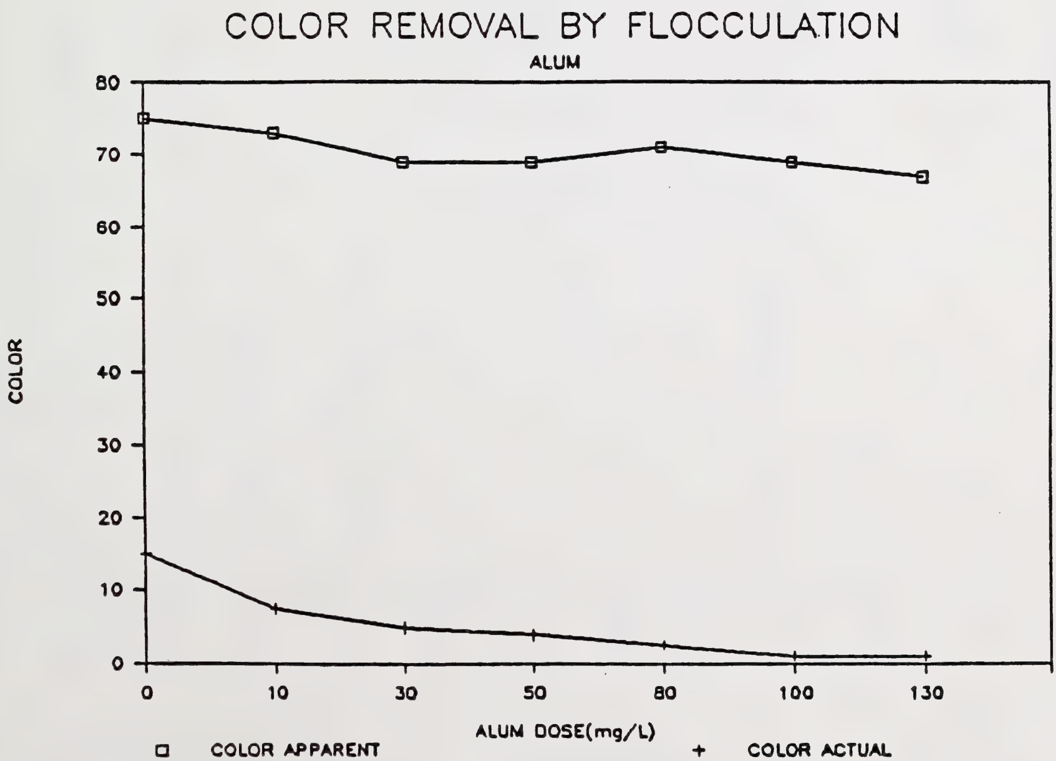
COLOR REMOVAL EFFICIENCY
BENCH TESTS 04/88
COLOR REMOVAL (%)
100
90
80
70
60
50
40
30
20
10
0
OZONE (19 mg/L)
CARBON FILTRATION
ALUM (130 mg/L)
ALUM/NaCO3 (440 mg/L)
ALUM/CaCO3 (130 mg/L)
POLY ALUMINUM CHLORIDE (130 mg/L)
TREATMENT
APPARENT COLOR
ACTUAL COLOR

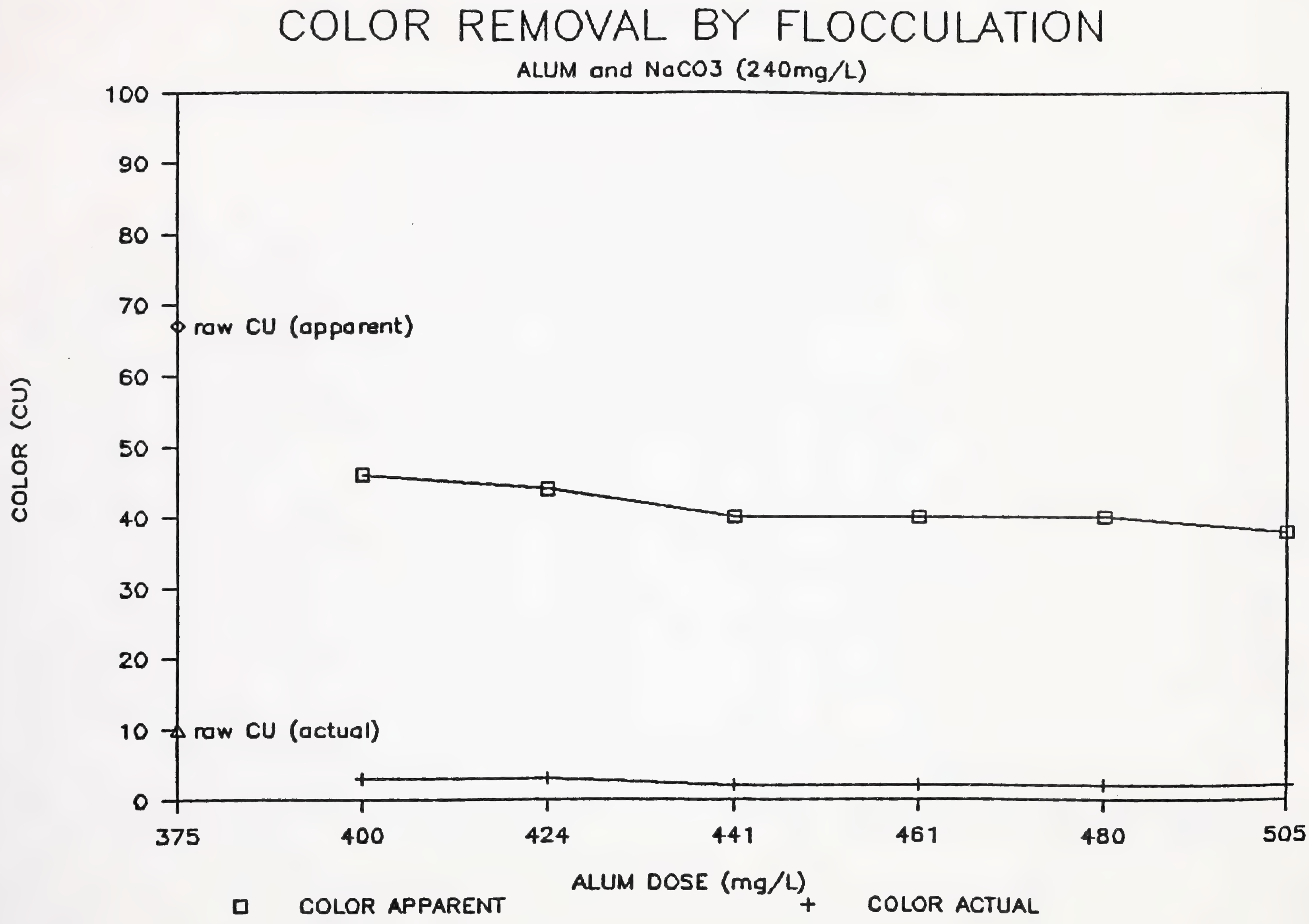
COLOR REDUCTION BY OZONATION

ELK ISLAND SOURCE WATER



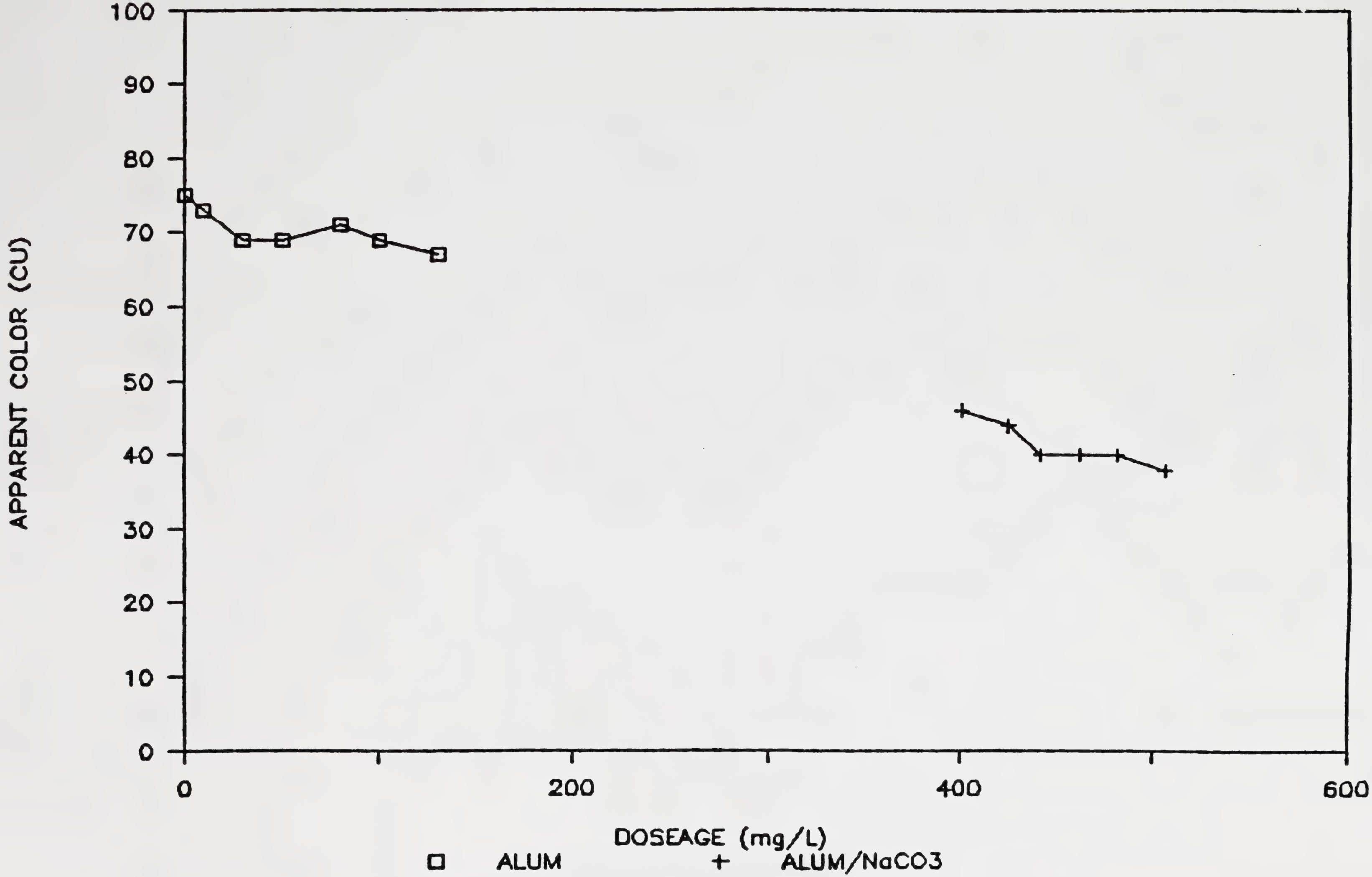

COLOR REMOVAL BY FLOCCULATION
ALUM (ACTUAL COLOR)
ACTUAL COLOR
ALUM DOSE(mg/L)

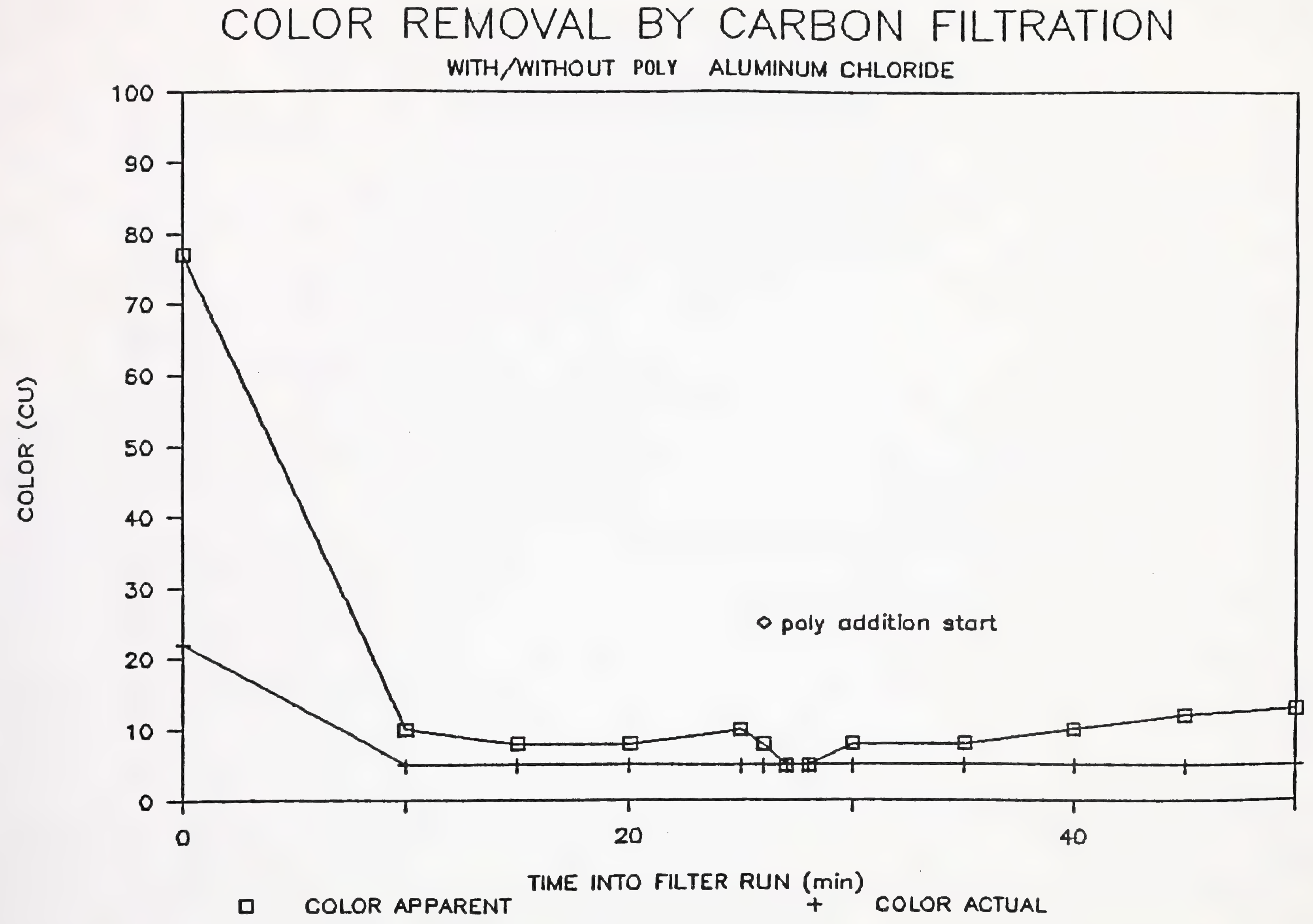

COLOR REMOVAL BY FLOCCULATION
ALUM
COLOR
ALUM DOSE(mg/L)
COLOR APPARENT
COLOR ACTUAL


COLOR REMOVAL BY FLOCCULATION
ALUM and NaCO3 (240mg/L)
COLOR (CU)
100
90
80
70
60
50
40
30
20
10
0
raw CU (apparent)
raw CU (actual)
375
400
424
441
461
480
505
ALUM DOSE (mg/L)
COLOR APPARENT
COLOR ACTUAL

APPARENT COLOR REMOVAL BY FLOCCULATION

ALUM AND ALUM/NaCO3





COLOR REMOVAL BY CARBON FILTRATION
WITH/WITHOUT POLY ALUMINUM CHLORIDE
COLOR (CU)
100
90
80
70
60
50
40
30
20
10
0
◇ poly addition start
0
20
40
TIME INTO FILTER RUN (min)
□ COLOR APPARENT
+ COLOR ACTUAL

APPENDIX C

LAB DATA

PROCESS CONTROL LABORATORY

WATER PROFILE AND COAGULATION TEST

SAMPLE: ELK ISLAND RAW WATER DATE SAMPLED: FEBRUARY 11, 1988

pH	COND µS	TURB FTU	TEMP °C	COLOUR APPARENT CU	COLOUR FILTERED CU	Fe PPM	Mn PPM	Ca PPM	Mg PPM	COLOUR ACTUAL CU
8.18	330	4.0	9		* 16					

TRIAL # DATE:

BEAKER #	FILTER AID ____ (gm)	FILTER AID ____ (gm)	APPEARANCE OF FLOC	pH	COLOUR APPARENT CU	COLOUR FILT 0.80µM CU	COLOUR ACTUAL CU FILT-pH 7.6
1							
2							
3							
4							
5							
6							
BLANK							

Stirring Conditions: ________ minutes at 100 RPM, ________ minutes at 50 RPM
Comments:

* Filtered using 0.45 µm membrane.

HH/bad 0949A 2440-CS9 88.03.11

PROCESS CONTROL LABORATORY

WATER PROFILE AND COAGULATION TEST

SAMPLE: Elk Island Raw Water DATE SAMPLED: March 24, 1988

pH	COND µS	TURB FTU	TEMP °C	COLOUR APPARENT CU	COLOUR FILTERED CU	Fe PPM	Mn PPM	Ca PPM	Mg PPM	COLOUR ACTUAL CU
8.33	412	6.6		89	13	0.03	0.10			

HH/bad
0949A
2440-CS9
88.04.08

PROCESS CONTROL LABORATORY

WATER PROFILE AND COAGULATION TEST

SAMPLE: ELK ISLAND RAW WATER DATE SAMPLED: FEBRUARY 11, 1988

pH	COND µS	TURB FTU	TEMP °C	COLOUR APPARENT CU	COLOUR FILTERED CU	Fe PPM	Mn PPM	Ca PPM	Mg PPM	COLOUR ACTUAL CU

TRIAL # DATE: MARCH 2, 1988

BEAKER #	FILTER AID POLY (gm) ALUMINIUM CHLORIDE	FILTER AID ______ (gm)	APPEARANCE OF FLOC	pH	COLOUR APPARENT CU	COLOUR FILT 0.80µM CU	COLOUR ACTUAL CU FILT-pH 7.6
1	0.01			8.02	79	17	
2	0.03			7.88	87	15	
3	0.05			7.83	79	15	
4	0.08			7.77	79	12.5	
5	0.10			7.52	69	12.5	
6	0.13			7.54	69	10	
BLANK							

Stirring Conditions: 5 minutes at 100 RPM, 15 minutes at 50 RPM

Comments: Blank was not run.

HH/bad 0949A 2440- CS9 88.03.11

PROCESS CONTROL LABORATORY

WATER PROFILE AND COAGULATION TEST

SAMPLE: Elk Island Raw Water DATE SAMPLED: March 3, 1988

pH	COND µS	TURB FTU	TEMP °C	COLOUR APPARENT CU	COLOUR FILTERED CU	Fe PPM	Mn PPM	Ca PPM	Mg PPM	COLOUR ACTUAL CU
8.45	301	4.5		75	15	0.02	0.03			

TRIAL # 1 DATE: March 4, 1988

BEAKER #	FILTER AID Alum (gm)	FILTER AID ____ (gm)	APPEARANCE OF FLOC	pH	COLOUR APPARENT	COLOUR FILT 0.80µM	COLOUR ACTUAL FILT-pH 7.6
1	0.01			8.05	73	7.5	
2	0.03			7.68	69	5.0	
3	0.05			7.42	69	4.0	
4	0.08			7.17	71	2.5	
5	0.10			7.05	69	1.0	
6	0.13			6.89	67	1.0	
BLANK					75	15.0	

Stirring Conditions: Initial 3 minutes on high, then 15 minutes on 50 RPM

Comments:

HH/bad 0949A 2440-CS9 88.03.11

PROCESS CONTROL LABORATORY

WATER PROFILE AND COAGULATION TEST

SAMPLE: Elk Island Raw Water DATE SAMPLED: March 3, 1988

pH	COND µS	TURB FTU	TEMP °C	COLOUR APPARENT CU	COLOUR FILTERED CU	Fe PPM	Mn PPM	Ca PPM	Mg PPM	COLOUR ACTUAL CU
8.45	301	4.5		75	15	0.02	0.03			

TRIAL # 1 DATE: March 4, 1988

BEAKER #	FILTER AID Alum (gm)	FILTER AID ______ (gm)	APPEARANCE OF FLOC	pH	COLOUR APPARENT	COLOUR FILT 0.80µM	COLOUR ACTUAL FILT-pH 7.6
1	0.01			8.05	73	7.5	
2	0.03			7.68	69	5.0	
3	0.05			7.42	69	4.0	
4	0.08			7.17	71	2.5	
5	0.10			7.05	69	1.0	
6	0.13			6.89	67	1.0	
BLANK					75	15.0	

Stirring Conditions: Initial 3 minutes on high, then 15 minutes on 50 RPM

Comments:

HH/bad 0949A 2350-AB5-2 88.03.11

PROCESS CONTROL LABORATORY

WATER PROFILE AND COAGULATION TEST

SAMPLE: Elk Island Raw Water DATE SAMPLED: March 3, 1988

pH	COND µS	TURB FTU	TEMP °C	COLOUR APPARENT CU	COLOUR FILTERED CU	Fe PPM	Mn PPM	Ca PPM	Mg PPM	COLOUR ACTUAL CU
				69	13					

TRIAL # 2 DATE: March 8, 1988

BEAKER #	FILTER AID NaCO3 (gm)	FILTER AID Alum (gm)	APPEARANCE OF FLOC	pH	COLOUR APPARENT CU	COLOUR FILT 0.80µM CU	COLOUR ACTUAL CU FILT-pH 7.6
1	0.238	0.40			46	7.5	
2	0.239	0.42			46	3.0	
3	0.238	0.44			48	3.0	
4	0.239	0.46			44	3.0	
5	0.239	0.48			48	3.0	
6	0.238	0.50			35	2.0	
BLANK					69	13.0	

Stirring Conditions: Initial 3 minutes at 100 RPM, then 15 minutes at 50 RPM

Comments: pH's were not recorded

HH/bad 0949A 2350-AB5-2 88.03.11

PROCESS CONTROL LABORATORY

WATER PROFILE AND COAGULATION TEST

SAMPLE: Elk Island Raw Water

DATE SAMPLED: March 3, 1988

pH	COND µS	TURB FTU	TEMP °C	COLOUR APPARENT CU	COLOUR FILTERED CU	Fe PPM	Mn PPM	Ca PPM	Mg PPM	COLOUR ACTUAL CU
8.34	464	5.3	20	67	10					

TRIAL # 3

DATE: March 15, 1988

BEAKER #	FILTER AID $NaCO_3$ (gm)	FILTER AID Alum (gm)	APPEARANCE OF FLOC	pH	COLOUR APPARENT CU	COLOUR FILT 0.80µM CU	COLOUR ACTUAL CU FILT-pH 7.6
1	0.239	0.400		6.96	46	3	
2	0.239	0.424		6.88	44	3	
3	0.239	0.441		6.86	40	2	
4	0.239	0.461		6.82	40	2	
5	0.239	0.480		6.78	40	2	
6	0.239	0.505	Light - some floc floated after 2 hrs.	6.70	38	2	
BLANK				8.34	67	10	

Stirring Conditions: 3 minutes at over 100 RPM, 15 minutes at 50 RPM

Comments: Different carboy than previous March 3 samples, although they were sampled at the same time.

HH/bad 0949A 2350-AB5-2 88.03.11

PROCESS CONTROL LABORATORY

WATER PROFILE AND COAGULATION TEST

SAMPLE: Elk Island Raw Water

DATE SAMPLED: March 3, 1988

pH	COND µS	TURB FTU	TEMP °C	COLOUR APPARENT CU	COLOUR FILTERED CU	Fe PPM	Mn PPM	Ca PPM	Mg PPM	COLOUR ACTUAL CU
8.31	463	5.5	24°	65	10					

TRIAL # 4

DATE: March 18, 1988

BEAKER #	FILTER AID $CaCO_3$(gm)	FILTER AID Alum(gm)	APPEARANCE OF FLOC	pH	COLOUR APPARENT CU	COLOUR FILT 0.80µM CU	COLOUR ACTUAL CU FILT-pH 7.6
1	0.1	0.01	pin point	8.00	79	10	
2	0.1	0.03		7.68	65	8	
3	0.1	0.05		7.46	65	7	
4	0.1	0.08	Light Fluffy	7.24	71	5	
5	0.1	0.10		7.12	65	5	
6	0.1	0.13		7.01	65	5	
BLANK				8.31	65	10	

Stirring Conditions: 3 minutes at 100 RPM, 15 minutes at 50 RPM

Comments: $CaCO_3$ for turbidity added prior to alum, didn't distribute well .. mix Alum, then add $CaCO_3$

HH/bad 0949A 2350-AB5-2 88.03.11

PROCESS CONTROL LABORATORY

WATER PROFILE AND COAGULATION TEST

SAMPLE: Elk Island Raw Water

DATE SAMPLED: March 3, 1988

pH	COND µS	TURB FTU	TEMP °C	COLOUR APPARENT CU	COLOUR FILTERED CU	Fe PPM	Mn PPM	Ca PPM	Mg PPM	COLOUR ACTUAL CU
8.33	471	4.6	25	67	15					

TRIAL # 5

DATE: March 22, 1988

BEAKER #	FILTER AID Alum (gm)	FILTER AID $CaCO_3$(gm)	APPEARANCE OF FLOC	pH	COLOUR APPARENT CU	COLOUR FILT 0.80µM CU	COLOUR ACTUAL CU FILT-pH 7.6
1	0.01	0.10	Pin Point	8.02	71	10	
2	0.03	0.10		7.67	63	10	
3	0.05	0.10		7.46	67	8	
4	0.08	0.10	Light Fluffly	7.25	71	7	
5	0.10	0.10		7.14	71	7	
6	0.13	0.10		7.02	73	5	
BLANK				8.33	67	15	

Stirring Conditions: 3 minutes at 100 RPM, 15 minutes at 50 RPM

Comments: Added the $CaCO_3$ while stirring at 100 rpm. The Phipps and Bird paddle stirring unit does not lend itself well to turbidity addition.

HH/bad 0949A 2350-AB5-2 88.03.11

PROCESS CONTROL LABORATORY
DECOLOURIZATION BY OZONATION

SAMPLE: ELK ISLAND RAW WATER

DATE SAMPLED: MARCH 24, 1988

OZONE GENERATOR 30 SCFH AND 1 AMP DATE TESTED: MARCH 25, 1988

SAMPLE TIME (MIN)	COLOUR APPARENT CU	COLOUR FILTERED CU	pH	OZONE CONC. GM/HR
0	81	15	8.31	7.45
0.5	63	8	8.33	
1.0	52	7	8.28	
1.5	48		8.25	
2.0	42	7	8.22	
2.5	38		8.19	
3.0	35	5	8.17	
3.5	31		8.16	
4.0	31	5	8.17	
4.5	29		8.15	
5.0	29	5	8.14	
FINAL				7.18
BENCH TEST SCRUBBER				6.58

HH/bad
0993C
2440-CS4
8.04.05

PROCESS CONTROL LABORATORY
DECOLOURIZATION BY FILTRATION

SAMPLE: ELK ISLAND RAW WATER

METHOD: CARBON FILTER

DATE SAMPLED: MARCH 24, 1988

DATE TESTED: APRIL 11, 1988

TEST # 1

SAMPLE TIME (MIN)	COLOUR APPARENT CU	COLOUR FILTERED CU	pH	OZONE CONC. GM/HR
0	77	22	8.01	N/A
10	10	< 5	7.32	
15	8	< 5	7.45	
20	8	< 5	7.51	
25	10	< 5	7.59	

HH/bad
0993C
2440-CS9
88.04.12

PROCESS CONTROL LABORATORY
DECOLOURIZATION BY FILTRATION

SAMPLE: ELK ISLAND RAW WATER

METHOD: CARBON FILTER WITH POLY ALUMINIUM CHLORIDE (0.0999g)

DATE SAMPLED: MARCH 24, 1988

DATE TESTED: APRIL 11, 1988

TEST # 2

SAMPLE TIME (MIN)	COLOUR APPARENT CU	COLOUR FILTERED CU	pH	OZONE CONC. GM/HR
1	8	< 5	7.58	N/A
2	5	< 5	7.64	
3	5	< 5	7.68	
5	8	< 5	7.73	
10	8	< 5	7.77	
15	10	< 5	7.82	
20	12	< 5	7.86	
25	13	< 5	7.91	

HH/bad
0993C
2440-CS9
88.04.12

Alberta
ENVIRONMENTAL CENTRE

P.O. Bag 4000
Vegreville, Alberta T0B 4L0
(Telephone 632 - 6761 Ext. 255)

LAB SAMPLE NO. 2142

CHEMICAL ANALYSIS REQUEST

AEC..................

Results to:
Name (Print) Brian Gray
Address AEC
ET
Phone 231

PROJECT NO.

Sample Origin	Sampled by	Description
Company/ Municipality AEC	Name Hugh	☐ Groundwater ☐ Grab
Location	Phone 231	☒ Lake/River ☐ Composite
RAW 1	Date 3 MAR/88	☐ Sewage Duration ___ hrs.
ELK ISLAND	Time ___ AM/PM	☐ Industrial Frequency ___ hrs.
Depth ___ meters		☐ Sediment

ROUTINE	METALS	ORGANICS	NUTRIENTS	CARBONS
☑ 2 pH	☑ 49 Cd	☑ 17 COD	☐ 31 TP	☑ 39 DOC
☑ 3 Conductivity	☑ 45 Cu	☐ 18 BOD	☐ 32 TKN	☑ 77 DIC
☑ 16 HCO$_3$	☑ 47 Ni	☐ 93 BOD(Filt)	☐ 88 TP(Diss)	☑ 76 TC(Part)
☑ 15 CO$_3$	☑ 44 CO	☐ 19 DO	☐ 90 TKN(Diss)	
☑ 68 T-Alkalinity	☑ 52 Zn	☐ 20 Oil & Grease	☐ 89 TP (Part)	
☐ 6 Na	☑ 59 Al	☑ 29 Phenols	☐ 90 TKN (Part)	
☐ 7 K	☑ 53 Be	☐ 35 Cyanide	☑ 20 NH$_3$-N	
☑ 12 Cl	☑ 46 Mn	☑ 36 Sulfide	☐ 63 NH (Part)	
☐ 9 SiO$_2$	☑ 50 Cr	☐ 71,72,73 Color	☐ 85 PO$_4$	
☑ 4 Ca	☑ 55 V	☐ 30 MBAS	☐ 86 (NO$_3$+NO$_2$)-N	
☑ 5 Mg	☑ 58 Mo	☐ 25 NFR	☐ 87 NO$_2$-N	
☑ 67 T-Hardness	☑ 51 Pb	☐ 24 FR		
☑ 8 Fe	☐ 38 Cr^{16}	☐ 23 TR		
☑ 13 SO$_4$	~~42 Hg~~	☑ 33 Tannin&Lignin		
☐ 10 (NO$_3$+NO$_2$)-N	☑ 40 As	☐ 21 Odor		
☐ 11 NO$_2$-N	☑ 41 Se	☐ 27 Turbidity		
☐ 14 F	☐ 54 Ag	☐ 60 Haloforms		
☑ 69 TDS (Calc)	☐ 56 Ba	☐		
	☐			

NOTES ___

CHEM. ANALYSIS REPORT

LOCATION : U K VILLAGE RAW 1 ETW

LAB NO. 2142-S DATE REC D 07/03/88 DATE COMPLETED 08/04/88

PARAMETER	CODE	MG/L	PARAMETER	CODE	MG/L
PH	10301L	8.3	CONDUCTIVITY	02041L	494.
IRON	26304L	0.02*	TDS	00205L	274.
CALCIUM	20110L	35.	MAGNESIUM	12303L	29.
HARDNESS T	10602L	206.	SODIUM	11103L	25.
POTASSIUM	19103L	17.0	SILICA	14107L	6.2
NO2 + NO3	07105L	0.02*	NITRITE	07205L	0.005*
FLUORIDE	09107L	0.20	CHLORIDE	17203L	5.
SULFATE	16306L	10.	BICARBONATE	06201L	311.
ALKALINITY T	10101L	255.	COD	08304L	85.0
DOC	06107L	30.4	TC (PARTIC)	06905L	2.28
DIC	06154L	56.5	AMMONIA	07562L	0.044
PHENOLS	06537L	0.010	T & L	06551L	0.50
SULFIDE	16101L	0.02*	ARSENIC	33011L	0.0005
SELENIUM	34011L	0.0002*	COBALT	27009L	0.001*
COPPER	29009L	0.002	NICKEL	28009L	0.005
CADMIUM	48009L	0.003	LEAD	82302L	0.003*
ZINC	30009L	0.017	MANGANESE	25003L	0.030
CHROMIUM	24009L	0.004	BERYLLIUM	04103L	0.001*
VANADIUM	23009L	0.004	MOLYBDENUM	42009L	0.002
ALUMINUM	13306L	0.020*	BARIUM	56009L	0.052
TN (PARTIC)	07906L	0.39			

SUM OF CATIONS 5.65 SUM OF ANIONS 5.46

BALANCE 1.04

* INDICATES CONCENTRATION LESS THAN . CONDUCTIVITY REPORTED IN MICROSIEMENS/CM. PH IN PH UNITS. ALKALINITY AND HARDNESS EXPRESSED AS CALCIUM CARBONATE. NITRITE AND NITRATE + NITRITE EXPRESSED AS N.

FE, VA, PB, AL, AG EXPRESSED AS EXTRACTABLE. ALL REMAINING METALS EXPRESSED AS TOTAL. PHOSPHORUS, T AND PHOSPHORUS DISSOLVED ORTHO EXPRESSED AS P. AMMONIA EXPRESSED AS N. TURBIDITY REPORTED IN NTU.

******* NOTE: NO VALUE
TDS - TOTAL DISSOLVED SOLIDS
NO2 = NITRITE
NO3 = NITRATE

CERTIFIED.......................................FOR
DR. F.P. DIEKEN, HEAD, WATER ANALYSIS & RESEARCH SECTION, CHEMISTRY WING
ALBERTA ENVIRONMENTAL CENTRE
VEGREVILLE TELEPHONE 632-6767. EXT.256.

Alberta ENVIRONMENTAL CENTRE

P.O. Box 4000
Vegreville, Alberta T0B 4L0
(Telephone 632 - 6761 Ext. 2531)

LAB SAMPLE NO. 2144

CHEMICAL ANALYSIS REQUEST

AEC..................

Results to:
Name (Print) Brian Gray
Address AEC

Phone ET 231

PROJECT NO.

Sample Origin	Sampled by	Description
Company/ Municipality AEC	Name Hugh	☐ Groundwater ☐ Grab
Location TREATED LAK ISLAND	Phone 231	☒ Lake/River ☐ Composite
	Date 3 MAR/88	☐ Sewage Duration ___ hrs.
	Time ______ AM/PM	☐ Industrial Frequency ___ hrs.
Depth ______ meters		☐ Sediment

ROUTINE	METALS	ORGANICS	NUTRIENTS	CARBONS
☑ 2 pH	☑ 49 Cd	☑ 17 COD	☐ 31 TP	☑ 39 DOC
☑ 3 Conductivity	☑ 45 Cu	☐ 18 BOD	☐ 32 TKN	☑ 77 DIC
☑ 16 HCO3	☑ 47 Ni	☐ 93 BOD(Filt)	☐ 88 TP(Diss)	☑ 76 TC(Partic)
☑ 15 CO3	☑ 44 Co	☐ 19 DO	☐ 90 TKN(Diss)	
☑ 68 T-Alkalinity	☑ 52 Zn	☐ 20 Oil & Grease	☐ 89 TP (Part)	
☐ 6 Na	☑ 59 Al	☑ 29 Phenols	☐ 90 TKN (Part)	
☐ 7 K	☑ 53 Be	☐ 35 Cyanide	☑ 78 NH3-N	
☑ 12 Cl	☑ 46 Mn	☐ 36 Sulfide	☐ 63 TN (Part)	
☐ 9 SiO2	☑ 50 Cr	☐ 71,72,73 Color	☐ 85 PO4	
☑ 4 Ca	☑ 55 V	☐ 30 MBAS	☐ 86 (NO3+NO2)-N	
☑ 5 Mg	☑ 58 Mo	☐ 25 NFR	☐ 87 NO2-N	
☑ 67 T-Hardness	☑ 51 Pb	☐ 24 FR		
☑ 8 Fe	☐ 38 Cr+6	☐ 23 TR		
☑ 13 SO4	~~☐ 42 Hg~~	☑ 33 Tannin&Lignin		
☐ 10 (NO3+NO2)-N	☑ 40 As	☐ 21 Odor		
☐ 11 NO2-N	☑ 41 Se	☐ 27 Turbidity		
☐ 14 F	☐ 54 Ag	☐ 60 Haloforms		
☑ 69 TDS (Calc)	☐ 56 Ba	☐		
	☐			

NOTES ______

CHEM. ANALYSIS REPORT

LOCATION : U K VILLAGE TR ETW

LAB NO. 2144-S DATE REC D 07/03/88 DATE COMPLETED 08/04/88

PARAMETER	CODE	MG/L	PARAMETER	CODE	MG/L
PH	10301L	8.1	CONDUCTIVITY	02041L	515.
IRON	26304L	0.02*	TDS	00205L	284.
CALCIUM	20110L	31.	MAGNESIUM	12303L	29.
HARDNESS T	10602L	196.	SODIUM	11103L	29.
POTASSIUM	19103L	18.0	SILICA	14107L	5.4
NO2 + NO3	07105L	0.06	NITRITE	07205L	0.006
FLUORIDE	09107L	0.22	CHLORIDE	17203L	18.
SULFATE	16306L	17.	BICARBONATE	06201L	288.
ALKALINITY T	10101L	236.	COD	08304L	75.8
DOC	06107L	29.3	TC (PARTIC)	06905L	0.78
DIC	06154L	55.2	AMMONIA	07562L	0.037
PHENOLS	06537L	0.010	T & L	06551L	0.36
ARSENIC	33011L	0.0006	SELENIUM	34011L	0.0002*
COBALT	27009L	0.002	COPPER	29009L	0.002
NICKEL	28009L	0.005	CADMIUM	48009L	0.003
LEAD	82302L	0.003*	ZINC	30009L	0.010
MANGANESE	25003L	0.025	CHROMIUM	24009L	0.005
BERYLLIUM	04103L	0.001*	VANADIUM	23009L	0.009
MOLYBDENUM	42009L	0.002	ALUMINUM	13306L	0.242
BARIUM	56009L	0.048	TN (PARTIC)	07906L	0.12

SUM OF CATIONS 5.65 SUM OF ANIONS 5.60

BALANCE 1.01

* INDICATES CONCENTRATION LESS THAN . CONDUCTIVITY REPORTED IN MICROSIEMENS/CM. PH IN PH UNITS. ALKALINITY AND HARDNESS EXPRESSED AS CALCIUM CARBONATE. NITRITE AND NITRATE + NITRITE EXPRESSED AS N.

FE, VA, CO, AL, AG EXPRESSED AS EXTRACTABLE. ALL REMAINING METALS EXPRESSED AS TOTAL. PHOSPHORUS, T AND PHOSPHORUS DISSOLVED ORTHO EXPRESSED AS P. AMMONIA EXPRESSED AS N. TURBIDITY REPORTED IN NTU.

******* NOTE: NO VALUE
TDS - TOTAL DISSOLVED SOLIDS
NO2 - NITRITE
NO3 - NITRATE

CERTIFIED..............................FOR
DR. F.P. DIEKEN, HEAD, WATER ANALYSIS & RESEARCH SECTION, CHEMISTRY WING
ALBERTA ENVIRONMENTAL CENTRE
VEGREVILLE. TELEPHONE 632-6767, EXT.256.

10.3 Interim Report

AN INTERIM REPORT

ON THE EVALUATION OF THE EFFECTIVENESS OF

TREATMENT PROCESSES ON ASTOTIN LAKE WATER

IN ELK ISLAND NATIONAL PARK

TECHNOLOGIST, PILOT PLANT OPERATIONS

B. GRAY, P.Eng.

JUNE 23, 1989

INTRODUCTION

In the spring of 1988 a preliminary study was undertaken to determine the possibilities in treating the water from Astotin Lake in Elk Island National Park to acceptable drinking water standards. The results of this study were promising and showed potential in three treatment areas. These were ozonation, Granular Activated Carbon filtration, conventional coagulation treatment, or a combination of the above. Based on these results a more extensive treatment research program was planned and initiated. The results of the first stage of the research project will be presented in this report along with recommendations for work in the completion stage of the project and modifications to the Elk Island Administrative Site Plant required to assist in carrying out this research work.

SUMMARY

The results of the first stage of experiments show that ozone treatment by itself will remove significant amounts of apparent and actual colour from the Astotin Lake water but will not produce aesthetically acceptable drinking water during all the seasonal variations of the raw water quality. Granular Activated Carbon filtration by itself performs in a similar manner to ozone treatment with the likely added operating expense of replacing the carbon bed on a frequent basis as its capacity is used up from the high organic loading. A combination of ozonation followed by carbon filtration shows better potential for colour removal but has not shown the likelyhood of producing aesthetically acceptable water year round and would still require the frequent replacement of the carbon filter media. Direct sand filtration with filter aids can remove portions of apparent colour from the raw water but does not have the potential to provide high quality water. The conventional clarification/filtration process in place at Elk Island has the potential to produce safe drinking water if operated in an optimum manner but still would suffer from taste and odour problems when the incoming water quality deteriorated.

RECOMMENDATIONS

Based on the data indications and plant observations the recommended plan of action for the 1989 experimental phase will consist of:

Setup and operation of the Elk Island Administration Site Water Treatment Plant for an extended period to provide optimum performance within manpower and resource constraints. Within this scope the effects of rapid mixing, system flowrate, and polymer coagulation aids on the system performance could be studied. This would require modifications to the existing plant as outlined below to provide more efficient operation and effective monitoring of plant performance.

Diversion of a portion of the treated water stream to an ozonation/ Granular Activated Carbon system to evaluate on a daily basis the effectiveness and need for this process as a polishing step to the water treatment. This would also require a modification to the existing plumbing as outlined below.

Use of a modified taste and odour panel consisting of on-site volunteers to evaluate the aesthetic acceptance or rejection of samples from the different processes.

Provision of basic training on water treatment plant operation to the current operator as part of the experimental work. This would be approximately 3 hours per day and would improve the continuing operation of the water treatment plant after the experimental project was finished.

ELK ISLAND WATER TREATMENT PLANT MODIFICATIONS

To provide a more efficient operation and more effective monitoring of treatment performance during the proposed experimental schedule the following modifications will be required on the Elk Island Plant:

Flowmeters with recording devices (ie totalizers) on the inlet and outlet of the water treatment system. This will allow better monitoring of flow to

determine chemical doses for the system. A totalizing flowmeter on the distribution system would also allow more accurate tracking of water demand.

A connection to the outlet of the Elk Island filter to divert a portion of the filtered water to the ozonation/GAC system as shown on the accompanying figure 1.

Installation of a sampling point on the piping entering the reservoir to monitor the chlorine levels in the treated water.

Modifications to the sludge sampling points to connect to the inner cone mixing chamber to provide a clearer indication of clarifier flocculation status. Details of these changes are shown on the figure 2.

Replacement of current chemical feed system with a proposed setup as illustrated in figure 3. This would require new chemical solution tanks and modifications to the chemical feed plumbing to provide draw down tubes and indicating flowmeters. The purchase of a spare chemical feed pump for backup should also be considered.

Addition of a chemical feed ports and a rapid mix chamber to the inlet piping of the clarifier. This is shown in figure 4.

Modification of the current backwash system to provide adequate flow to properly backwash to the existing filter.

Consideration should also be given to installing a simple control system for the long term operation of a GAC filter to evaluate the overall capacity of GAC operating under these conditions and to implementing a water quality monitoring and record keeping system to allow long term evaluation of plant performance.

PREAMBLE

After Ray Howe from Parks Canada initially contacted Dr. Albert van Roodselaar at the Alberta Environmental Centre concerning the possibility of

testing the ozone treatability of the Elk Island National Park water bench scale experiments were initiated on two samples collected from Astotin Lake via the Administrative Site Plant raw water supply. Tests were done on the water using different treatment methods of ozonation sand filtration granular activated carbon filtration and jar tests using alum. Based on these results a two month field study combined with ongoing sampling and evaluation was undertaken. The results so far of these studies is what will be presented in this report.

SCOPE OF WORK

The scope of work for the field study included the evaluation of various water treatment processes to determine their applicability to the Astotin Lake water. These included conventional filtration with filter aids ozonation carbon filtration ozonation combined with carbon filtration and optimum operation the existing water treatment plant combined with preozonation and post ozonation of the water. Measurements of colour pH and turbidity were used to evaluate the acceptance or rejection of these processes. An informal sniffing panel was also used to evaluate the odour problems associated with the water. Ongoing samples of the raw water were collected and evaluated for quality and ozone treatability.

METHODOLOGY

Measurements

The procedure for testing ozone gas flows as part of the ozone treatment evaluation employing a scrubber system was taken from "Standard Methods for the Examination of Water and Wastewater 16th Edition". The scrubber design is illustrated in figure 5.

The scrubber bottles used were 4 litre glass winchesters with rubber stoppers. Tygon tubing and glass dispersion rods were used to connect the scrubbers in series and parallel. A 200 g/l potassium iodide (KI) scrubbing solution was used. This solution was prepared in 10 litre carboys and stored in a cooler. During the tests the scrubbing chain was placed in an ice bath.

The principle of this analytical method is as follows: 1) Ozone liberates iodine from a potassium iodide solution. 2) After the reaction a 0.005 M sodium thiosulfate solution was used with statch indicator to titrate the iodine produced. The sodium thiosulfate was standardized using potassium dichromate.

The volume of KI solution in the scrubbers was determined experimentally (500 ml, 1000 ml, 1500 ml and 2000 ml) to ensure effective iodine levels for the titration. All titrations were performed within 10 minutes of the completion of ozone collection.

The number of scrubber bottles in the chain varied from a maximum of seven to a minimum of five. During all the tests performed the final two scrubbers in the chain showed no visible orange colour indicating that no ozone reached them.

Within the scope of this paper water colour was determined by the following measurements.

1. Actual Colour

Actual colour refers to the colour of a sample after filtration through a 0.8 um nylon membrane without pH adjustment to the sample. The absorbence of the samples is measured using a BRINKMANN dipping probe colourimeter model PC 800 at a wavelength of 470 nm and this value is then compared to a series of platinum cobalt standards. The concentration using Beers Law is then determined and reported in colour units (CU).

2. Apparent Colour

The apparent colour is determined on the original water sample without filtration or pH adjustment. The absorbence is read on a BRINKMANN dipping probe colourimeter at a wavelength of 470 nm. The absorbence value is compared to a series of platinum cobalt standards and the concentration using Beers Law is then determined and reported in colour units (CU).

Turbidity was measured in units of NTU using a bench top HACH Ratio Turbidimeter. A sample of the water to be tested was placed in a clean glass measurement cell. This cell is then placed in the precalibrated Ratio Turbidimeter and the turbidity value was recorded from the digital display.

Measurement of pH was performed using a bench top CORNING model 135 pH meter. The pH meter was first calibrated by placing the probe in known pH buffer solutions and adjusting the meter to read correctly. The probe was then placed in the sample to be measured and the pH value was recorded from the digital display.

Experimental Setup

Field trials for ozone testing of water treatment were carried out using the Alberta Environmental Centre Ozone Treatment Trailer. Raw water was pumped from the inlet well in the Elk Island Administrative Site Water Treatment Plant to the inlet of the ozone trailer. The water was then treated with ozone using the output from an Azcozon ozone generator directed through bubble contact columns installed in the ozone trailer. Treated water was disposed of as waste. Schematic drawings of the ozone trailer and the bubble contact columns are included as figures 6 and 7. Ozone flows were measured on the gas inlet and outlet of the bubble column along with the water flow through the column. This allows the calculation of the dose of ozone consumed by the water in mg/l. The applied dose of ozone is higher and is dependant upon the design of the bubble contact column. Samples of raw and treated water were also collected to determine the values of colour, pH, and turbidity.

Bench scale treatment tests were carried out at the Alberta Environmental Centre using a 5 litre batch bubble column. The water sample was recirculated through the 3 inch diameter glass column as ozone from an Azcozon ozone generator was bubbled up through a frit at the bottom of the column. Measurements of the inlet and outlet ozone flows were taken at regular time intervals to allow the calculation of ozone used (demand) by the water in the column. Water samples were also taken at the same time intervals to determine the reduction of colour and turbidity by the treatment. A schematic drawing of the system included as figure no. 8.

Filtration experiments were conducted on site at Elk Island using a 6 inch diameter gravity filter column filled with sand or Granular Activated Carbon to an appropriate bed depth. Chemical filter aids as required were injected into the inlet of the filter using a chemical metering pump through an injection header. Operation of the filter was monitored by recording flowrates head loss through the filter and by collecting water samples which were analysed for colour, pH, and turbidity.

When conducting the evaluation of the Elk Island Plant performance and the effect of postozonation on water quality the existing plant was used with some minor changes. Flow through the plant was reduced to 37 l/min and alum with a polymer coagulation aid was injected into the clarifier inlet pipe using different solution tanks and chemical metering pumps. The clarifier was initially seeded with high doses of alum and polymer to promote flocculation. Water samples were collected from the raw flow clarifier effluent and filter outlet every hour and analysed for colour, pH, and turbidity. After continuous operation of the plant for approximately 24 hours had produced a stable output a portion of the treated water was pumped to the ozone trailer and a normal ozone treatment experiment was done on the water followed by filtration through Granular Activated Carbon using the 6 inch column filter.

The preozonation trial on the Elk Island plant was set up as follows. Raw water from the Elk Island Plant was pumped to the ozone trailer. Here the water was treated with ozone using the bubble contact column and alum with a polymer coagulation aid was injected. The water was then pumped back to the inlet of the Elk Island clarifier bypassing the cascade aerator. Ozone demand was tested every two hours and water samples were collected every hour and analysed for colour, pH, and turbidity. The plant was operated in this manner and its performance evaluated for 27 hours.

DISCUSSION OF RESULTS

Direct Filtration

Filter trials to determine the effectiveness of direct filtration on removing apparent colour from the water were done in July 1988 at the Elk Island Park Administration Site Water Treatment Plant. Experiments done using a sand filter without filter aids and with 50 mg/l doses of alum or poly aluminium chloride injected into the inlet stream of the filter resulted in a small apparent colour reduction of 10 to 15 CU resulting in a filtered colour of 35 to 50 CU depending on the raw water quality. There was not a significant reduction in actual colour through the filter. When the chemical doses of alum (150 mg/l) and poly aluminium chloride (75 mg/l) were raised the colour reduction was improved with apparent colour dropping from 100 CU on the inlet to approximately 40 CU on the outlet of the filter. The actual colour still was not removed with filtration at those conditions. The indications of these experiments show a good removal of apparent colour by filtration at high chemical filter aid doses but not to a low enough level to provide acceptable drinking water quality.

Another experiment was done by first treating the raw water with 15 mg/l of ozone and then filtering the ozonated water through a bed of Granular Activated Carbon (GAC). The results of this trial showed a good reduction of apparent colour from 75 CU to 30 CU and of actual colour from 32 CU to 10 CU. The resulting water was not completely acceptable to the informal odour panel though. Water quality produced by this process would also be dependant on the treatability of the water by ozone which varies seasonally.

During the Elk Island Administration Plant trial a modified version of this treatment process was run. A dose of alum at 195 mg/l was added to the water followed by ozonation and then filtration through a bed of GAC. The resulting water was very good with turbidities of less than 1 NTU and colours (both apparent and actual) of 5 CU. The water did not completely pass the informal odour panel due to a possible metallic taste. There could also be

difficulties with this process including high solids loading on the GAC filter or varying organic loads resulting in frequent backwashes and an uncertain lifetime for the GAC bed.

OZONATION

Results of field trials conducted at Elk Island National Park Administration site water treatment plant in late July 1988 showed an apparent colour removal from 75 Colour Units (CU) to a level of 30 CU with an applied ozone dose of 20 mg/l. A corresponding drop of actual colour from 30 CU to 10 - 12 CU is realized with the same ozone dose. Bench trials conducted at the same time produced similar results with an apparent colour removal from 75 CU to 25 CU and actual colour removal from 25 CU to 10 CU with an ozone dose of 20 to 25 mg/l. A bench test conducted in June 1988 showed better treatability to the water with colour removal of 66 CU to 23 CU (apparent) and 17 CU to 7 CU (actual) with an ozone dose of 15 mg/l. Evaluation of the water in August and September 1988 showed poorer water treatability with the August test requiring 45 mg/l to reduce apparent colour from 113 CU to 53 CU and actual colour from 16 CU to 8 CU. Results from September were nearly as bad with the Administration site sample requiring 30 mg/l of ozone to produce colour reductions of 81 CU to 40 CU (apparent) and 10 CU to 5 CU (actual). The one time Campground Site water sample required 45 mg/l of ozone to reduce apparent colour from 104 CU to 40 CU and actual colour from 10 CU to 5 CU. The sample taken in October 1988 showed better results with an apparent colour reduction from 72 CU to 25 CU and a reduction of actual colour from 18 CU to 5 Cu with an ozone dose of 30 mg/l. Tests conducted in January and February 1989 showed much improved water quality with ozone doses of 15 to 20 mg/l required to reduce the apparent colour from 39 CU to 10- 12 CU and the actual colour from 14 CU to 10 CU.

The interpretation of these results is that this process showed a significant reduction in the water quality parameters being monitored but during seasonal periods of less treatable raw water quality the ozonation process did not produce acceptable odour and colour free water. Therefore this process can not be relied upon alone to produce acceptable water quality all year round.

EXISTING PLANT OPERATION

Two trials were conducted using the Elk Island Water Treatment Plant as part of the experimental process. The purpose of these two trials was to evaluate the performance of the existing plant when operated under close to optimum conditions, the process of preozonating the water before it entered the plant and finally the effect of ozonation and carbon filtration on the water produced by the existing clarification /filtration process in the Elk Island Plant.

Doses of chemicals used were selected by jar tests carried out on-site in July 1988 to determine approximate ranges of chemical doses under the water conditions at that time.

A test combining the evaluation of the existing plant with the study of post ozonation of the water was conducted first over a two day period starting August 3, 1988. The plant was operated at a flow of 37 l/min with chemical doses of 250 mg/l of alum and 0.25 mg/l of polymer coagulation aid. The results of this test showed good colour and turbidity removals with apparent colour reduced from 80 CU to 10 CU, actual colour reduced to 5 CU from 20 CU and outlet turbidities of less than 1 NTU. The informal odour panel did not find this water to be aesthetically acceptable though.

When this water was then ozonated with 5 mg/of ozone and filtered through a GAC filter the resulting water had colours (both apparent and actual) of 5 CU and a turbidity of 0.2 NTU. The water was accepted by the informal odour panel with two objections to the chlorine added to the water for residual disinfection. Overall the Elk Island plant showed a potential for producing a good quality water although some final polishing step is still required to remove the taste and odour problem a provide a high quality drinking water.

Less than perfect positioning of monitoring points within the Elk Island clarifier led to misinterpretation of the clarifier performance which led to improper chemical doses being added. As a result the performance of the system was not steady throughout the experiment and did not show an overall consistent performance of the Elk Island system. A tight experimental schedule did not allow the repeat of the experiment in the 1988 season to show a longer steady state performance of the system.

The second experiment using the Elk Island Plant was done to evaluate the performance of preozonating the raw water before it entered the Elk Island Plant to provide better flocculation and colour removal through the microflocculation enhancement of ozonation. The experiment was conducted over a 30 hour period on August 9-10, 1988. The plant was operated at 25 l/min with chemical doses of 150 300 mg/l of Alum 0.2 mg/l of polymer coagulation aid and a 3 mg/l preozonation dose. The results of this trial were good with improved flocculation and stability of the floc blanket in the Elk Island clarifier. Apparent colour was reduced from approximately 110 CU to 5 CU on the outlet of the filter. Actual colour was also reduced from 20 CU to 5 CU. Turbidities on the filter outlet were also reduced to less than 1 NTU. Due to the nature of the experimental setup and lack of time to pursue the matter further it is not clear how much of the improved performance was due to the preozonation step and how much was due to the improved mixing and energy input of pumping the alum dosed water from the ozone trailer to the Elk Island Plant. The informal odour panel still did not find the treated water acceptable due to musty swampy odours which were identifiable when residual chlorine was added to the water.

COLOUR RETURN

Experiments on the return of colour to the water samples after being ozonated (at 25 & 12 days) did not show a significant increase in colour under likely storage conditions. The addition of chlorine after the water was ozonated did not seem to affect the return of colour. Most of the colour return was associated with long term storage of water at ambient room temperatures. This is not usually the case under projected operating conditions.

INDICATIONS

The results of the data collected to this point can be summarized as follows:

1. Direct filtration of the raw water with filter aids can remove portions of the apparent colour from the water. However it does not remove actual colour from the water and the resulting product is not aesthetically acceptable as drinking water.

2. Ozonation of the raw water can remove significant amounts of apparent and actual colour from the water. The effect of ozonation is variable as the quality of the incoming lake water changes. As a result the consistent operation to provide good quality water cannot be assured over the long term.

3. Ozonation followed by Granular Activated Carbon (GAC) filtration can provide good water treatment but will not produce water of high enough quality to be aesthetically acceptable as drinking water. It would also suffer from the same seasonal variations in treatment as straight ozonation.

4. The existing Elk Island Administration Site Water Treatment Plant has the potential to produce a consistent good quality water with a moderate amount of effort in operation and review. Water quality produced with this system alone would not be aesthetically acceptable throughout the entire year.

5. Treatment of a consistently good quality water produced by the existing plant could be enhanced by the addition of ozonation and carbon filtration treatment to the water already treated by the existing plant.

6. Colour return during storage of treated water is not likely to be a problem under current operating conditions.

7. Water sampled from Astotin Lake varies in quality and treatability with some of the worst cases occurring during the summer months.

OBSERVATIONS

1. Record keeping in the plant is minimal. The lack of flowmeters with totalizing devices and other monitoring equipment makes it difficult to accurately determine chemical dosages operating conditions and water demands. Without ongoing records concerning flows chemical doses and water quality it

is virtually impossible to evaluate the performance on the water treatment plant on a long term basis.

2. The backwash rate provided to the sand filter in the Elk Island Plant is too low to provide adequate backwashes to the filter. As measured by volume in August 1988 the backwash rate was approximately 9 USGPM/Sq. Ft. The recommended backwash rate for proper operation of filters is 15 USGPM/Sq. Ft.

3. Flocculation monitoring points in the Elk Island clarifier are inappropriately placed to give a representative picture of conditions within the clarifier. The outlet valves of the sampling points are not conveniently placed to encourage monitoring of clarifier operating conditions on a regular basis.

4. The chemical feed system is functional but could be improved to provide easier measurement of feed rates and chemical use. The injection points for

the chemicals are misplaced with alum and soda ash being injected at the same location. This reduces the effectiveness of alum for colour removal. Clarifier operation should be improved if the alum was injected upstream of the clarifier followed by a rapid mixing process to optimize coagulation and flocculation.

5. Clarifier operation would be improved if the process could be allowed to operate continuously or on longer cycles. Currently the plant operates on a 3 to 4 hour cycle producing approximately 3500 Imperial gallons of water. This utilizes only 20 % of the reservoir's 17,000 gallon capacity. If more of the reservoir's capacity was used the plant could operate for longer periods of time. Alternately the flow rate through the plant could be reduced to provide only the current distribution demand and allow the water treatment plant to operate on a continuous basis. This would improve clarifier operation but would place the filtration flow at a lower than optimum range. Close monitoring of water usage would also be required to avoid shortages.

SUMMER 1989 SCHEDULE

The purpose of the 1989 experimental evaluation is to study in depth the scenario of operating the existing plant under close to optimum conditions with polishing steps of ozonation and/or carbon filtration. The proposed schedule is to complete plant modifications and equipment set-up in July and August 1989 followed by a two to three week evaluation run. Activities activities in the evaluation run would include continued production of water using the modified existing plant, daily evaluation of ozonation and carbon filtration polishing steps, and basic training of operator in optimum plant operation. Evaluation of operating conditions would be carried out by monitoring typical water quality parameters and using a modified taste and odour panel consisting of volunteers from the park site to determine the acceptance of daily water samples.

BG/BG
1593C
89.06.23

2440-CS8-4

10.4 Acceptance of Tender

ACCEPTANCE OF TENDER
CONTRACT FOR PERFORMANCE
OF WORK

ACCEPTATION DE SOUMISSION
CONTRAT POUR L'EXÉCUTION
DE TRAVAUX

ALL CORRESPONDENCE & INVOICES MUST SHOW THE FILE & CONTRACT NUMBERS

LE NUMÉRO DU DOSSIER ET CELUI DU CONTRAT DOIVENT FIGURER DANS LA CORRESPONDANCE ET LES FACTURES

File No - Dossier no
C1632-149-88

Contract No - Contrat no
KWR8149(DO)

Authority - Autorisation
TB806000 S3 CIII

Fin. Code - Code fin.
9559-9851-88127-201

To - A
Alberta Environmental Centre
Bag 4000
Vegreville, Alberta
T0B 4L0

Work - Ouvrage
Pilot Water Plant Study
Elk Island National Park, Alberta

Your offer to supply the materials & to perform the work herein below stipulated at the prices shown is hereby accepted on the terms & conditions set out below.

Nous acceptons par les presentes, aux conditions stipulées ci-dessous, votre offre de fournir les materiaux et d'effectuer les travaux spécifiés ci-dessous aux prix indiqués.

Work - Ouvrage	Price - Prix
Description of Work	
To perform a pilot water plant study at Elk Island National Park, Alberta in accordance with the Terms of Reference dated July 12, 1988 which document is attached to and forming a part of this contract, to meet the requirements of Canadian Parks Service for the FIXED price of	$22,446.00
Method of Payment	
The total fixed price authorized herein shall be payable upon submission of detailed invoices for services rendered, all to the satisfaction of the Director General.	
Supplementary Conditions	
It is understood and agreed that:	
1. The terms and conditions of General Conditions (2)A (Form PC 556) attached hereto, insofar as they are not at variance with the terms and conditions herein contained, shall apply to and form part of this contract.	
2. The liability of Her Majesty in respect of this contract shall in no event whatsoever exceed the expenditure authorized herein without prior approval of the Director General by means of a specific formal amendment to this contract.	
3. The Contractor agrees to complete the work by October 31, 1988 (main pilot study) and March 31, 1990 (monitoring).	

Work – Ouvrage	Price – Prix

General Clause

It is a term of this contract that no former public office holder who is not in compliance with the post-employment provisions of the Conflict of Interest and Post-Employment Code for Public Office Holders shall derive a direct benefit from this contract.

Definitions

"Canadian Parks Service" means Environment Canada, Canadian Parks Service, Western Region.

"Director General" means Director General, Canadian Parks Service, Western Region, or his authorized representative.

"Contractor" means

Alberta Environmental Centre
Bag 4000
Vegreville, Alberta
T0B 4L0

TIME IS OF THE ESSENCE IN THIS CONTRACT.

$22,446.00

INVOICING INSTRUCTIONS – MODE DE FACTURATION

Send 1 copies together with all necessary certificates and declarations.
Envoyer copies avec tous certificats et attestations nécessaires
to / à Environment Canada, Canadian Parks Service, P.O. Box 2989, Station M, 552, 220 - 4 Avenue S.E., Calgary, Alberta T2P 3H8 Attention: Accounts Payable

Signed, sealed and delivered on behalf of Her Majesty – Signé, scellé et signifié au nom de Sa Majesté

by – par

In the presence of – En la présence de

Date

Signed, sealed and delivered – Signé, scellé et signifié

Contractor – Entrepreneur

In the presence of – En la présence de

Date

TERMS OF REFERENCE

PILOT WATER PLANT STUDY

ELK ISLAND NATIONAL PARK

BACKGROUND

The water supply serving the major facilities in Elk Island National Park is treated water from Astotin Lake. The water generally meets the required bacteriological and chemical criteria for drinking water but it has a taste and odor problem. The local Park employees generally haul their drinking water from the Regional Water District.

The objective is to provide a water supply of similar quality to the Regional water to eliminate the need to haul water and provide an acceptable quality for both public and private use. This could be provided in a number of ways but as a satisfactory ground water source is not available, it appears the best economic course would be to improve the treatment of the lake water.

As pointed out by Alberta Environment at our meeting of April 28, 1988, the quality of the treated water is a factor of not only the treatment method and equipment but of all operation and maintenance procedures. Therefore, the pilot study should also address these other factors where they can be tied into the pilot study.

SCOPE

The scope of the study and the results should include:

1. Monitoring of the seasonal variation in the quality of the raw water supply. This should also consider whether there is any difference in quality at different depths of water or locations in the lake in the vicinity of the present intake. This will involve taking samples once a month based on a two year cycle. Sampling scope will be limited by seasonal considerations such as ice conditions.

2. FIELD STUDY

a) To test under field conditions the result of ozonation, coagulation, and filtration in varying combinations to determine the optimum process. This will be undertaken utilizing a mobile pilot facility supplied by the Alberta Environmental Centre.

b) To monitor the operation of the existing plant to determine whether the plant can be adapted to the proposed treatment process.

c) A number of individuals on site (3 or 4) will be designated as official quality assessors of water palatibility. The evaluation by these individuals of water samples, they will be asked to assess, will be recorded and will constitute the measure of treated water acceptability.

3. A detailed report of the findings of the study will be prepared and will include an assessment of the current systems capability, the results of the filtration and coagulation studies and the impact of introducing ozone into the treatment protocol. Based on the results of 2(c), the acceptability of treated Astotin water will be examined with respect to the degree of treatment required.

Based on positive pilot results, the report would include:

a) Process options which would enhance plant operation and product quality.

b) Suggested changes and additions to the existing plant including equipment performance recommendations.

c) Recommended operating instructions for the plant based on alternative process sequence.

d) Operator training and awareness. (It is to be kept in mind that the plant is operated by the park on a part-time basis.)

COST OF STUDY

The cost of this study is to be jointly funded (50/50) by Parks Canada and he Alberta Environmental Centre based on the following cost estimate:

1. MONITORING SURVEY (2 years duration)

   Based on 12 samplings/year (once a month)

Operational - 12 man-days/year x $150/day	= $ 1,800.00
Laboratory - 18 man-days/year x $150/day	= 2,700.00
FOR ONE YEAR	= 4,500.00
TWO YEAR CYCLE	= $ 9,000.00

2. FIELD STUDY

   EQUIPMENT AND FACILITY

	CAPITAL x (2.5 months/5 x 12 months)		
Trailer	100,000	/ 24	= $ 4,166.00
Mobile Lab	40,000	/ 24	= 1,667.00
Lab Facility	35,000	/ 24	= 1,458.00

MANPOWER

	#	x	Monthly Salary	x	Months	
Operational	2	x	2,000	x	2.5	= $10,000.00
Laboratory	1.5	x	2,000	x	2.5	= 7,500.00
Engineering	.3	x	3,000	x	3	= 2,700.00
Management	.1	x	4,000	x	3	= 1,200.00
Support Services (Secretarial, Instrumentation, Maintenance)	.2	x	2,000	x	2.5	= 1,000.00

OPERATING

Chemical Costs (Plant)	= $ 500.00
Hoses & Hardware	= 700.00
Transportation	= 900.00
Chemical Costs (Laboratory)	= 600.00
TOTAL	= $32,391.00

3. REPORT

Engineering - 1 man-month x 3,000	= $ 3,000.00
Drafting	= 500.00
TOTAL	= $ 3,500.00
COST OF STUDY	= $44,891.00
COST TO PARKS CANADA	= $22,446.00

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10.5 Internal Planning Documents

10.5.1 Experimental Proposal

ELK ISLAND EXPERIMENTAL PROPOSAL

The intent of this proposal is to outline the ideal scenario of work to be done on the Elk Island project within the current expertise available within the Operations Branch.

The objectives of the work at Elk Island National Park Astotin Lake are three fold: firstly to operate the existing water treatment plant at the Elk Island Administrative Site within the Operations Branch's expertise to try to demonstrate the capability of that plant to produce a good quality water and achieve the potential hinted at by experiments done in the summer of 1988; secondly to train the current staff operating the Elk Island water treatment plant on how to better operate the plant and monitor the quality of water produced by the plant; thirdly to evaluate the effectiveness of using ozone and/or GAC to produce a high quality water from the existing plant's "good" quality water.

The first objective will be accomplished by operating the existing plant to the best ability of the available expertise within the Operations Branch while continually monitoring the water produced via analysis of water quality parameters and user acceptance. The second objective will be met by having Elk Island staff operate the plant with AEC personnel, receive training on the analysis of water samples to monitor the quality of water produced, and receive some basic instruction on the practice of drinking water treatment. The third objective will be accomplished by setting up and operating an ozone/GAC filtration column within the Elk Island plant in conjunction with operating the main plant while monitoring the water produced by this process via analysis of water quality parameters and user acceptance.

The work will require several phases and several elements to each phase.

PHASE I SETUP

At least one field trip will be required to evaluate the effectiveness and completeness of the modifications currently being undertaken at the site. Once these changes are complete approximately three man days will be required to finish the ozone/GAC column pack equipment and three man days will be required to setup the column and generator and lab facilities. Other work that may require extra time would be the proper setup of water treatment chemicals and commissioning of plant modifications that the current staff could not complete.

PHASE II START-UP OF PROJECT AND PLANT OPERATION

Time: Approximately 1 Week

Following setup, jar testing of the current water should be undertaken. Following the first day of this testing (including training for AEC personnel) it would be appropriate to train Elk Island personnel on the procedure when there would be minimal chance of confusing results which would increase the difficulty of teaching and learning the procedure. Also on the second day of this phase Elk Island personnel could receive initial training on the analytical procedures required to test the water samples from the jar tests. During this testing stage AEC personnel would become more familiar with the equipment including the chemical injection system, chlorine injection systems, electrical and flow systems, and work the bugs out of the ozone/GAC test columns. On the third day of the start-up phase the jar tests should supply enough information to assume an initial chemical dose and barring any equipment problems a start-up attempt of the clarifier could be tried. If initial estimated chemical doses are close enough and there are no equipment problems, stable clarifier operation should be obtained by the fifth day of this phase. Training of Elk Island personnel would continue through this start-up phase.

PHASE III PLANT OPERATION AND EXPERIMENTAL EVALUATION

Time: Approximately 3 Weeks

This phase would be initiated once stable clarifier operation was obtained. The filter would be vigorously backwashed to "start from scratch" and various lengths of filter runs would be evaluated. Water samples would be collected as often as possible (two to four times daily) from the raw, clarified, filtered and distributed water to be analysed for pH, turbidity, chlorine, color and UV absorbence. Chemical dosage would be adjusted according to these results and the indications of the V/V measurements and ongoing jar tests (once a day during this phase). Chlorine dose would be monitored and controlled if possible to maintain a constant acceptable dose.

The ozone/GAC column would be started up in the morning and operated throughout the day while AEC personnel were in attendance. Operation of the column would ideally be tested two times a day with five sample reps each for ozone dose (mass balance on column and water residual).

Other tests on the water would be daily odour profiles as determined by a panel of Elk Island residents and staff on samples taken from the raw water, the treated clarified/filtered water, and the polished ozonated/GAC filtered water. This would take approximately one to two operator hours to perform and require 1/2 to 1 hour of the panel's time. Initial training of volunteers and optimizing the procedure so that it was working well and useful results were being obtained would require two people from AEC at 2 hours/day. Another useful exercise would be daily comments and complaints about the quality of the water by anyone working or living at the Elk Island Administration site starting a week before the operation phase and continuing throughout the operational phase.

Training of Elk Island personnel during this phase should take about three hours a day split between jar tests, operating the plant, learning analytical procedures, performing analyses on water samples, maintaining records, and reviewing plant operation within the context of drinking water treatment practice. The ideal objective of this three week training period is that the

current staff will be able to start evaluating and making decisions to improve the operation of the plant.

Results of each day should be recorded and analysed on a daily basis to optimize the direction of the research and identify any procedural or analytical problems and correct them during the experimental trials rather than after the experiments are complete. This would take 2 to 3 hours of work by knowledgeable analyst each day. A daily report of the operation could easily be derived from this analysis.

PHASE IV COMPLETION

Time: 1 Year

When the experimental objectives have been accomplished, approximately two days (4 man days) will be required to shut down the plant, return it to operational status, remove experimental equipment, transport the said equipment back to AEC and store the it properly. To properly accomplish the monthly profile evaluation on the water from Elk Island National Park Astotin Lake will require 1 1/2 operation man days and approximately 2 lab man days every month with access to the ozone bench scale treatment unit. If possible a better bench system would be set-up to incorporate a clarifier/filter/ ozone/GAC system for testing but until a more complete bench scale system was functioning a batch type ozone demand test of the water would be performed monthly. The time and facility requirements for this work should be incorporated into the planning of all other work and projects.

Data for these monthly profile experiments should be returned as soon as possible, collated, and analysed to maintain an up-to-date status of this project and identify any problems in the procedures as soon as possible to minimize wasting samples and experimental work.

ANALYTICAL REQUIREMENTS

PHASE I

In terms of samples there would not be any analytical requirements in this phase but the lab could be expected to work on refining and training on the KI techniques of measuring ozone in water solution and in the gas phase. Other work could be done on setting up spreadsheets or other programs to handle the raw data from the ozone and colour and various other measurements with the capability to present a hard copy or disk output of the results within the required time period. Also included in this phase would be the time required to move and set up the mobile lab at the Elk Island site with the required equipment.

PHASE II

The work in this phase would mainly involve jar tests and performing tests on the samples. Each jar test would require the analysis of seven samples for pH, turbidity, colour, UV at 200 and 254 nm, and dose of soda ash required to neutralize the pH. The first two days three jar tests per day would be performed After this one jar test per day would be performed along with other work. The other work would consist of testing for pH, turbidity, colour and UV at 200 and 254 nm of 1 or 2 water surveys per day consisting of five samples each . Alkalinity of the raw water once per day would be desirable. Some testing of the ozone testing procedures and measurement methodology would be required to work the bugs out of the ozone/GAC system (approximately 1 test per day consisting of four ozone air samples and two ozone water samples). Data from all these tests would preferably be received as soon as possible after performing the tests but no later than the end of that working day.

PHASE III

The work in this phase would consist of one jar test per day, three plant surveys per day consisting of five samples each, three tests of the ozone

system per day with five repetitions per test (10 ozone air samples and five ozone water samples per test). Alkalinity of the raw water once per day would be desirable. The preparation of approximately 40 250/500 mL odour free glass Erlymer flasks per day would also be required for the odour profile tests. Data from all these analyses would preferably be received as soon as possible after performing the tests but no later than the end of that working day.

PHASE IV

This phase would require the ongoing testing of the Elk Island water once per month. This test would require the testing of raw, treated, and distribution water for as many parameters as possible (a full Chemistry evaluation would be desirable), a bench scale ozone test measuring ozone, colour, UV, pH, and turbidity. If possible a better bench system would be set-up to automate some of the measurements and incorporate a clarifier/ filter/ozone/GAC system for testing but until a more complete bench scale system was functioning a batch type ozone demand test of the water would be performed monthly. This bench scale plant would then require regular survey samples for colour and UV be taken and initial samples on the other parameters to assist in calibrating the on-line monitors. Data from these tests should be returned within one week of performing the experiment.

ANALYTICAL TESTS

Plant Survey

Five Samples

RAW:
Analysis Required:
pH, turbidity, colour, UV at 200 and 254 nm, alkalinity (once per day)

CLARIFIED WATER:
Analysis required:
pH, turbidity, colour, UV at 200 and 254 nm

FILTERED WATER:

Analysis required:

pH, turbidity, colour, UV at 200 and 254 nm

DISTRIBUTION WATER:

Analysis required:

pH, turbidity, colour, UV at 200 and 254 nm, and chlorine

OZONATED/GAC FILTERED WATER:

Analysis required:

pH, turbidity, colour, UV at 200 and 254 nm

OZONE TESTS

To evaluate the performance of the ozone column.

Do mass balance on column by measuring generator output and off gas concentration and ozone content of water. Repeat these samples/measurements (5) five times to get a significant number through statistics.

JAR TESTS

Evaluate chemical doses. Operators will perform jar tests and give seven water samples to lab for analysis of pH, turbidity, colour, UV at 200 and 254 nm and the dose of soda ash required to bring the sample back to neutral pH on some selected samples.

ODOUR PROFILES

Prepare odour free glassware for use in these panel evaluations and possibly assist in performing these evaluations.

ELK ISLAND PROJECT ESTIMATED WORK SCHEDULE

PHASE I SETUP WEEK 1	TIME	OPERATOR 1	OPERATOR 2	ASSISTANT	ELK ISLAND PERSONNEL TRAINING
Day 1	8:15 - 9:00	Completion	Completion		
	9:00 - 10:00	of test	of test		
	10:00 - 11:00	Column	Column		
	11:00 - 12:00	and Packing	and Packing		
	12:00 - 1:00				
	1:00 - 2:00				
	2:00 - 3:00				
	3:00 - 3:30				
	3:30 - 4:30				
Day 2	8:15 - 9:00	Details	Last Details		
	9:00 - 10:00	Travel	Travel		
	10:00 - 11:00	Unload	Unload		
	11:00 - 12:00	Unload	Unload		
	12:00 - 1:00	Lunch	Lunch		
	1:00 - 2:00	Setup Column	Setup Column		
	2:00 - 3:00	Setup Column	Setup Column		
	3:00 - 3:30	Setup Column	Setup Column		
	3:30 - 4:30	Travel	Travel		
Day 3	8:15 - 9:00	Travel	Travel		
	9:00 - 10:00	Connect Column	Connect Column		
	10:00 - 11:00	Connect Column	Connect Column		
	11:00 - 12:00	Connect Column	Connect Column		
	12:00 - 1:00	Lunch	Lunch		
	1:00 - 2:00	Familiarize	Familiarize		
	2:00 - 3:00	with Plant	with Plant		
	3:00 - 3:30	Set-up Jars	Set-up Jars		
	3:30 - 4:30	Travel	Travel		

Day 4	8:15 - 9:00	Travel	Travel
	9:00 - 10:00	Set-up Jars	Set-up Jars
	10:00 - 11:00	Set-up Plant	EI Plant Work
	11:00 - 12:00	Set-up Plant	EI Plant Work
	12:00 - 1:00	Lunch	Lunch
	1:00 - 2:00	Set-up Plant	EI Plant Work
	2:00 - 3:00	Set-up Jars	Set-up Jars
	3:00 - 3:30	Set-up Jars	Set-up Jars
	3:30 - 4:30	Travel	Travel

PHASE II SETUP WEEK 1	TIME	OPERATOR 1	OPERATOR 2	ASSISTANT	ELK ISLAND PERSONNEL TRAINING
Day 1	8:15 - 9:00	Travel	Travel	Travel	
	9:00 - 10:00	Jar Test	Jar Test	Jar Test	
	10:00 - 11:00		and Training Hugh	Jar Test	
	11:00 - 12:00	Jar Test	Jar Test	Jar Test	
	12:00 - 1:00	Lunch	Jar Test	Lunch	
	1:00 - 2:00	Jar Test	Lunch	Jar Test	
	2:00 - 3:00	Jar Test	Jar Test	Jar Test	
	3:00 - 3:30	Jar Test	Input Data	Jar Test	
	3:30 - 4:30	Travel	Travel	Travel	
Day 2	8:15 - 9:00	Travel	Travel	Travel	
	9:00 - 10:00	Jar Test	Training	Jar Test	Operator 2
	10:00 - 11:00	Jar Test	Analysis Data	Jar Test	Operator 1
	11:00 - 12:00	Jar Test	Jar Test	Jar Test	Lab
	12:00 - 1:00	Jar Test	Lunch	Lunch	
	1:00 - 2:00	Lunch	Jar Test	Jar Test	
	2:00 - 3:00	Jar Test	Analyse Data	Jar Test	
	3:00 - 3:30	Jar Test	Analyse Data	Jar Test	
	3:30 - 4:30	Travel	Travel	Travel	

Day 3	8:15 - 9:00	Travel	Travel	Travel	
	9:00 - 10:00	Plant	Plant	Plant	
	10:00 - 11:00	Start-up	Start-up	Start-up	Operator 1&2
	11:00 - 12:00	Start-up	Start-up	Start-up	
	12:00 - 1:00	Lunch	Start-up	Lunch	
	1:00 - 2:00	Start-up	Lunch	Jar Test	
	2:00 - 3:00	Chemical and	Chemical and	Jar Test	
	3:00 - 3:30	Operation	Operation		
	3:30 - 4:30	Travel	Travel	Travel	
Day 4	8:15 - 9:00	Travel	Travel	Travel	
	9:00 - 10:00	Start-up	Analyse Data	Assist Op.	Operator 1
	10:00 - 11:00	Operation	Analyse Data		Lab
	11:00 - 12:00	Operation	Training	Assist Op.	Operator 2
	12:00 - 1:00	Lunch	Lunch	Lunch	
	1:00 - 2:00	Jar Test and	Ozone	Jar Test	
	2:00 - 3:00	Operation	Ozone	Jar Test	
	3:00 - 3:30	Operation	Input Data	Jar Test	
	3:30 - 4:30	Travel	Travel	Travel	
Day 5	8:15 - 9:00	Travel	Travel	Travel	
	9:00 - 10:00	Startup & Samples	Analyse Data	Jar Test	Lab
	10:00 - 11:00	Jar Test	Analyse Data	Jar Test	Operator 1
	11:00 - 12:00	Jar Test & Op.	Training	Jar Test	Operator 2
	12:00 - 1:00	Lunch	Lunch	Lunch	
	1:00 - 2:00	Operation	Ozone	Assist with	
	2:00 - 3:00	Operation	Odour Test	Ozone and	
	3:00 - 3:30	Operation	Odour Test	Operation	
	3:30 - 4:30	Travel	Travel	Travel	

PHASE III SETUP WEEK 3	TIME	OPERATOR 1	OPERATOR 2	ASSISTANT	ELK ISLAND PERSONNEL TRAINING
Day 1	8:15 - 9:00	Travel	Travel	Travel	
	9:00 - 10:00	Start-up	Ozone	Assist with	
	10:00 - 11:00	Operation	Ozone	Ozone and	Operator 1
	11:00 - 12:00	Operation	Training	Operation	Operator 2
	12:00 - 1:00	Lunch	Lunch	Lunch	
	1:00 - 2:00	Odour Test	Odour Test	Jar Test	Lab
	2:00 - 3:00	Odour Test	Odour Test	Jar Test	
	3:00 - 3:30	Operation	Input Data	Jar Test	
	3:30 - 4:30	Travel	Travel	Travel	
Day 2	8:15 - 9:00	Travel	Travel	Travel	
	9:00 - 10:00	Start-up	Analyse Data	Assist with	
	10:00 - 11:00	Operation	Analyse Data	Ozone and	Operator 1
	11:00 - 12:00	Ozone	Training	Operation	Operator 2
	12:00 - 1:00	Lunch	Lunch	Lunch	
	1:00 - 2:00	Odour Test	Ozone	Jar Test	Lab
	2:00 - 3:00	Operation	Operation	Jar Test	
	3:00 - 3:30	Operation	Operation	Jar Test	
	3:30 - 4:30	Travel	Travel	Travel	
Day 3	8:15 - 9:00	Travel	Travel	Travel	
	9:00 - 10:00	Start-up	Analyse Data	Assist with	
	10:00 - 11:00	Operation	Analyse Data	Ozone and	Operator 1
	11:00 - 12:00	Ozone	Training	Operation	Operator 2
	12:00 - 1:00	Lunch	Lunch	Lunch	
	1:00 - 2:00	Ozone	Odour Test	Jar Test	Lab
	2:00 - 3:00	Operation	Operation	Jar Test	
	3:00 - 3:30	Operation	Operation	Jar Test	
	3:30 - 4:30	Travel	Travel	Travel	

Day 4	8:15 - 9:00	Travel	Travel	Travel	
	9:00 - 10:00	Start-up	Analyse Data	Assist with	
	10:00 - 11:00	Operation	Analyse Data	Ozone and	Operator 1
	11:00 - 12:00	Ozone	Training	Operation	Operator 2
	12:00 - 1:00	Lunch	Lunch	Lunch	
	1:00 - 2:00	Odour Test	Ozone	Jar Test	Lab
	2:00 - 3:00	Operation	Operation	Jar Test	
	3:00 - 3:30	Operation	Operation	Jar Test	
	3:30 - 4:30	Travel	Travel	Travel	
Day 5	8:15 - 9:00	Travel	Travel	Travel	
	9:00 - 10:00	Start-up	Analyse Data	Assist with	
	10:00 - 11:00	Operation	Analyse Data	Ozone and	Operator 1
	11:00 - 12:00	Ozone	Training	Operation	Operator 2
	12:00 - 1:00	Lunch	Lunch	Lunch	
	1:00 - 2:00	Odour Test	Ozone	Jar Test	Lab
	2:00 - 3:00	Operation	Operation	Jar Test	
	3:00 - 3:30	Operation	Operation	Jar Test	
	3:30 - 4:30	Travel	Travel	Travel	

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10.5.2 Elk Island Work Program

ELK ISLAND WORK PROGRAM (FALL 1989)

This is a description of activities to be undertaken to address the produced water quality problem at the Elk Island National Park Astotin Lake Administrative Site Water Treatment Plant. What follows is proposed steps to improve the plant operation, provide training to Elk Island personnel, and initiate a long term ongoing evaluation of Astotin Lake water quality and the water treatment plant operation. A more extensive, analytically supported evaluation of Elk Island Plant operation and the suitability of ozone or Granular Activated Carbon (GAC) in the treatment process has not been included here. That aspect of the project could be undertaken when AEC resources were more easily available and Astotin Lake water conditions were more suitable for optimum data collection.

To improve plant operation at Elk Island and try to produce a more consistent, better quality water. B. Gray and H. Mack would travel to the Elk Island site for a period of two weeks on a daily basis. While monitoring water quality using some field analytical equipment (pH meter, turbidity meter, chlorine measurement device, Hach colour kit, and a jar test apparatus) on site and bringing some samples back to the Process Control Lab for UV analysis, B. Gray and H. Mack would try to operate the plant to its potential to produce an acceptable quality water. Evaluation of plant operation would be determined by informal odour profile tests, review of water quality data measured using field water quality equipment, and informal feedback from the people living and working at Elk Island.

Elk Island personnel would attend daily training sessions approximately three hours long, consisting of practices in plant operation, water quality analysis, jar testing, record keeping, and review of the plant's operation with respect to water treatment practices.

After this two week training/operating period by AEC personnel the staff operating the Elk Island plant would then continue with what should be a better quality operation. They would perform water quality tests on an

ongoing basis while maintaining up-to-date records. To perform the water quality tests the Elk Island staff will require some measuring equipment. This should consist of a pH meter, turbidity meter, colour measurement device, chlorine measurement device and if possible a jar test apparatus. The success of this part of the project would require a commitment from the Elk Island Administration and water plant staff to produce a consistent good quality water for use at the Elk Island site.

B. Gray will produce record keeping forms to be used during the two week test and afterwards by the Elk Island personnel operating the water treatment plant. Ongoing collection and evaluation of these records by AEC personnel will help determine variations in water quality and likely long term operating level of the plant.

A 2" stainless steel carbon (GAC) column will be installed at the outlet of the Elk Island filter. Its operation will be controlled by a solenoid valve actuated electrically to open whenever the plant is operating with pumps and clarifier on. A person from AEC will collect samples from the carbon column outlet and backwash it if necessary once every week. Long term evaluation of the water quality from the carbon column will assist in determining the feasibility of installing a GAC filter as a polishing water treatment step.

A water sample will be collected every month from the Elk Island raw water supply and studied for treatability by a batch type ozone demand test. This sample and other samples from the Elk Island plant's treated water will be analysed for as many parameters as possible by either the Process Control Lab or the AEC Chemistry Division.

The time involved to undertake these activities is as follows:

Production of usable record keeping forms for the Elk Island Plant will take approximately two days of work by B. Gray.

Set up of the 2" carbon column could be accomplished in one day in the Elk Island site once the solenoid wiring was in place. If a fresh carbon with documented characteristics is required for this test approximately one day of

phone calls would be required to order it. The time required to receive the carbon should also be considered.

Setup at Elk Island should be accomplished in two days once the plant modifications are complete. A two week operating/training period with B. Gray and H. Mack on site would follow. Some analytical equipment support and analysis of UV samples would be required from the Process Control Lab.

The ongoing monthly sample and ozone testing of the Astotin Lake water would require 1 1/2 operation man days and 2 lab man days per month with access to the ozone bench scale system.

Maintenance and sampling of the GAC column on site at Elk Island would require one man day each week. One or two man days per week of lab time would also be required depending on the extent of analysis undertaken on the samples.

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10.6 Surveys

10.6.1 July 1988 Questionnaire

Environment Canada / Environnement Canada

Parks / Parcs

Our file / Notre référence

Your file / Votre référence

July 29, 1988

Dear _______________:

You lucky person. You have been personally selected to fill out the enclosed questionnaire on "water" found in Elk Island National Park. It is a short questionnaire and shouldn't take too much of your time to complete, and it is very important to the future quality of water here in the park.

Please fill out sometime during the next week and return to Pat by next Friday.

Thanks,

Pat

Canada

Alberta
ENVIRONMENTAL CENTRE

BAG 4000, VEGREVILLE, ALBERTA T0B 4L0 403/632-6767

ELK ISLAND NATIONAL PARK WATER USE QUESTIONNAIRE

NAME AND OCCUPATION (Optional): ______________________________

1. How long have you worked in the Park?

2. Do you live in the Park?

3. If so, for how long?

4. Do you use the current water distributed within the park?

5. Do you use the water for different functions at different times of the year?

6. If you use the current water for any of the following check the corresponding box and estimate how often per week it is used for this purpose or how much (in gallons or litres) water is used per week for this purpose.

   [ ] DRINKING

   [ ] COOKING

   [ ] SHOWERING & BATHING

   [ ] BATHROOM

   [ ] HOUSECLEANING

   [ ] WASHING CARS

   [ ] WATERING LAWNS OR GARDENS (hours per week)

   [ ] OTHER

7. Do you treat the tap water in any way before using it? How?

8. Does the water quality vary?

9. If so, on what frequency? (daily, weekly, monthly, yearly)

10. Do you find any objectionable tastes or odours in the water?

11. If so, can you describe them?

12. At what times of the year are these problems the worst?

13. Do you use water from other sources?

14. If so, from where and for what use?

15. Is the water objectionable at certain times of the year?

16. Is the water acceptable at certain times of the year?

IF YOU HAVE ANY QUESTIONS CONCERNING THIS QUESTIONNAIRE, PLEASE CONTACT BRIAN GRAY AT 632-6761

BG/bd, 2440-CS8-4, 1170C, 88.07.25

10.6.2 August 1990 Questionnaire

Environment Canada
Canadian Parks Service

Environnement Canada
Service canadien des parcs

Our file Notre référence

Your file Votre référence

August 20, 1990

MEMO TO:

Park Staff

RE: Administration Area Domestic Water Supply

During the past year, several initiatives have been undertaken to increase the quality of water in the Admin. Area. At this time it is felt that water quality has improved significantly.

The attached questionnaire provides an opportunity for you to make comments and provide information that may assist General Works in producing an acceptable, or better quality, of water.

I would appreciate you taking time to complete the questionnaire and returning it to me by September 7, 1990.

Don Macaulay

Don Macaulay
General Works Manager
Elk Island National Park

Alberta
ENVIRONMENTAL CENTRE
BAG 4000. VEGREVILLE, ALBERTA T0B 4L0

ELK ISLAND NATIONAL PARK - WATER USE QUESTIONNAIRE
FOLLOW UP VERSION AUGUST 1990

NAME (optional): ______________________

) Did you participate in the July 1988 questionnaire?

) How long have you worked in the park?

) Do you live in the park? If so, for how long?

) Do you use more, or less, park water than you did one year ago?

(A) Less (B) The same (C) More (D) Much more

) Has the water quality varied in the last year?

) If so, when and how often (ie once, daily, weekly ect.) and in what way (better, worse or different)?

Do you find any objectional tastes, odours or other asthetic problems in the water? If so, can you describe them?

8) If you described problems, have there been months when it appears to be worse than others? When?

9) Are there times when the water appears to be better than normal? When?

10) Mark the uses that you currently have for the park water. Please use the scale to indicate the level of desirability of this water for each useage.

		NOT SUITABLE					VERY SUITABLE
[ ]	DRINKING	0	1	2	3	4	5
[ ]	COOKING	0	1	2	3	4	5
[ ]	SHOWER/BATHING	0	1	2	3	4	5
[ ]	BATHROOM	0	1	2	3	4	5
[ ]	LAUNDRY	0	1	2	3	4	5
[ ]	HOUSECLEANING	0	1	2	3	4	5
[ ]	YARD USE	0	1	2	3	4	5
[ ]	OTHER (specify)	0	1	2	3	4	5

11) What level of confidence would you have in the safety of the Edmonton water supply, if you lived in that city?

UNSAFE TO DRINK					SAFE TO DRINK
0	1	2	3	4	5

.2) Do you treat the water distributed by the park, in any way, before using it? How?

.3) Did you use any kind of treatment of your tap water one year ago? How, if different from question (12)?

.4) Do you use water from other sources? If so, from where?

.5) Has this changed in the last year? In what way?

.6) If you have any comments, or feel that this questionnaire does not give an accurate picture of your water situation, please use this space.

10.6.3 Odour Panel Sheets

ELK ISLAND WATER EVALUATION TESTS

Thank you for participating in this evaluation.

When evaluating the water samples the criteria is whether or not the water is aesthetically acceptable for use as drinking water. The samples that you will be presented with are not necessarily disinfected and may contain bacteria or other organisms. Therefore when assessing the water samples base your judgements on sight and smell.

When testing the water for smell clear your nose by smelling a cup of clean water and waiting at least 15 seconds between samples.

Fill out the form by indicating (yes/no) whether the sample is aesthetically acceptable to drink.

If the sample is not acceptable, rate its unacceptability on a scale of 1 to 5 (5 being the worst). If possible give details of what element of the water is unacceptable (i.e. a certain type of smell in the water).

ELK ISLAND WATER EVALUATION

DATE: ______________________ TEST #: ______________________

EVALUATOR: ____

SAMPLE NO.	ACCEPTABLE (YES/NO)	UNACCEPTABILITY RATING	DETAILS OF UNACCEPTABILITY
1	________	________	________________ ________________ ________________
2	________	________	________________ ________________ ________________
3	________	________	________________ ________________ ________________
4	________	________	________________ ________________ ________________
5	________	________	________________ ________________ ________________
6	________	________	________________ ________________ ________________
7	________	________	________________ ________________ ________________

ELK ISLAND WATER EVALUATION TESTS - SAMPLE SHEET

DATE: ____________________ TEST #: ____________________

SAMPLE DESCRIPTION: ____________________

____

SAMPLE NUMBERS ON CUPS

EVALUATOR NUMBER	RODI	EDMONTON WATER	TEST SAMPLE	TEST SAMPLE WITH CHLORINE

BG/bd

1161C

88.07.19

2440-CS8-4

10.6.4 Survey Results - Summary Tables

10.6.4 SURVEY RESULTS - SUMMARY TABLES

Comparable Notes Between the Two Surveys

July 1988 survey = 22 respondents
August 1990 survey = 21 respondents

Reply	1988 response	1990 response
# who use distiller in office:	9 yes 13 no	11 yes 10 no
# who use carbon as extra treatment:	3 yes	1 yes
# who use water from other sources:	12 yes 4 no	6 yes 15 no
variations in water quality ?	23 descriptors 4 no variation	6 descriptors 5 no variation
taste & odour descriptions:	-	2 no objection
	10 high chlorine	3 chlorine
	12 swampy/sloughy	3 swampy/sloughy
	1 sulphur	1 sour gas smell
	2 stale/stagnant	-
	-	1 distinct
	-	2 moldy/musty
	-	2 taste & odour of chlorinated lake water
	-	1 sour
	-	1 chemical taste
	-	1 organic taste
	3 other or undefined negative	-
totals	28	19
times better than normal or acceptable?	6 yes 3 questionable, marginal	2 yes 1 unsure
times worst or worse than normal?	3 no 5 yes 3 summer/spring	1 no - 4 summer/spring 1 fall 2 winter (chlorine)

Comparison of two surveys - continued

comments (not specifically asked for in 1988):	4 deposits/films/ stains (white,red, brown scum)	1 deposits
	3 brown/ yellow colour	-
	1 imports flavour to food	-
	-	2 kills plants
	-	1 still chlorine variation but better than last year
	-	1 better than last year
	-	1 great improvement

Summary July 1988 questionnaire

22 respondents = 11 park resident + 11 commute to park

resident and drink water:	1 yes	10 no
non-resident in park and drink water: (some uncertainty in above due to role of distiller)	6 yes	5 no
resident and use distiller:	6 yes	5 no
non-resident and use distiller:	3 yes	8 no
resident and bring in other water for use:	6 yes (5 Edm.)	5 no
non-resident and bring water for use:	6 yes (2 Edm.)	5 no

using other additional treatment of water -

resident:	3 (carbon)
non-resident:	1 (boil)

noted frequency of water quality variation -

resident	non-resident
2 none	2 none
1 unsure	4 no reply
2 daily	-
3 weekly	-
4 monthly	2 monthly
1 yearly	2 yearly
1 spring	3 spring/summer

taste & odour descriptions:

10 high chlorine
12 swampy/sloughy
1 sulphur
2 stale/stagnant
3 other or undefined negative

July 1988 questionnaire - continued

	resident	non-resident
times acceptable?	2 yes 3 questionable, marginal	4 yes 1 marginal
times worst?	1 no 4 yes 1 summer	2 no 1 yes 1 summer 1 spring

comments (not specifically asked for in 1988):

4 deposits/films/ stains (white,red, brown scum)
3 brown/yellow colour
1 imports flavour to food

Summary of August 1990 Survey

21 respondents = 12 live in park + 9 don't live in park

Scale:
Level of Desirability of Water

# who rated water at indicated level for:	0 not suitable	1	2	3	4	5 very suitable	avg. rating
drinking	6	6	4	2	1	0	1.3
cooking	0	0	5	4	2	1	2.9
showers	0	0	2	5	2	4	3.6
bathroom	1	0	0	2	6	11	4.3
laundry				4	4	4	4.0
all other	2	0	1	4	4	9	3.8
safety of Edmonton water	0	2	1	1	10	4	3.7

additional treatment used:

1 carbon
11 distiller

other sources of water used:

2 Edmonton
1 bottled
2 other
1 lake (for plants)

variation in quality noted:

5 none
1 occasional
3 weekly
2 in chlorine

August 1990 Survey - continued

descriptors used (may be more than one per person):	3 no reply 3 swampy/sloughy 3 chlorine (no degree given) 2 no objection 2 taste & smell like chlorinated lake water 2 unspecified smell 1 musty 1 moldy 1 distinct flavour 1 sour gas smell 1 sour 1 chemical taste 1 organic taste
months worse than others?	7 no reply 3 no 1 not in last several months 1 minor changes during water line breaks 1 last winter (chlorine) 3 spring/early summer 1 summer 1 unsure 1 in February 1 last fall 1 yes,no pattern
times better than normal?	7 no reply 6 no 3 not in last several months 2 unsure 1 mid-summer 2 yes, no pattern

comments:

- Bathroom cold water runs rusty at first.
- ...does not bother me, I find it fine.
- Better than last year.
- Great improvement.
- Better if had been asked to monitor usage, more meaningful answers.
- Some sludge (clay?) still on dish rack.
- I'm new, could get used to it.
- Kills house plants.
- Kills house plants.
- You know what has to be done. Don't waste my time with surveys like this.
- Chlorine variation, better than last year.

Odour panels results summary

yes means aesthetically suitable
no means aesthetically unacceptable

base samples - overall	RODI	=	18 yes	0 no
	Edm. water	=	16 yes	2 no
(1) ozonated lake water			2 yes	2 no
(2) + chlorine			4 yes	0 no
(3) ozonated water, sand filtered			2 yes	2 no
(4) + chlorine			2 yes	2 no
(5) ozonated water, carbon filtered			4 yes	0 no
(6) + chlorine			3 yes	1 no
(7) 1988 plant, EI run (has chlorine)			2 yes	2 no
(8) EI optimum performance		*	3 yes	1 no 1 ok
(9) + chlorine		*	3 yes	2 no
(10) EI optimum + post ozone		*	5 yes	0 no
(11) + chlorine		*	4 yes	1 no
(12) EI optimum + ozone + carbon filt.		*	5 yes	0 no
(13) + chlorine		*	3 yes	2 no
(14) EI optimum, pre ozonation			5 yes	0 no
(15) + chlorine			1 yes	4 no
(16) EI optimum, pre ozone + carbon filt.			4 yes	1 no
(17) + chlorine			2 yes	3 no

* indicates samples tested on day where both "no's" where given for Edmonton control sample.

comments given on samples:

RODI	2 clear
	1 slight taste
	1 no smell
Edm.water	1 same as (RODI), but better flavor
	1 slight smell
	1 ok taste
	2 clear
	1 no smell
	2 strong chlorine
(1) ozonated lake water	1 yellowish colour, flavor better than (ozone + filter)
	1 cloudy
(2) + chlorine	1 poorer colour, slightly yellow
	1 taste is acceptable
	1 clear
	1 ok for taste

Odour panel results - continued

(3) ozonated, sand filtered	1 colour poorer 1 taste somewhat acrid 1 cloudy 1 fair taste
(4) + chlorine	1 colour poorer, slight yellow 1 leaves after taste 1 some odour 1 poor taste
(5) ozonated, carbon filtered	1 clear 1 no smell
(6) + chlorine	1 slight colour
(7) 1988 EI plant, EI staff run (with Cl_2)	2 chlorine smell
(8) EI optimum performance	1 slight unidentified odour
(9) + chlorine	2 sloughy
(10) EI optimum, ozonated	0 comments
(11) + chlorine	1 slight yellow 1 skunky smell
(12) EI optimum, ozonated, carbon filtered	0 comments
(13) + chlorine	1 distinct odour, still drinkable 2 chlorine
(14) EI plant, pre ozonation	0 comments
(15) + chlorine	1 musty 2 chlorine 1 sloughy
(16) EI plant, pre ozonation, carbon polishing	1 metallic 1 slight organic
(17) + chlorine	2 slight odour 1 soda

10.6.5 Survey Results - Complete Tables

Elk Island Survey Results
JULY 88 RESULTS

* A = less than one year
B = one to two years
C = two to five years
D = over five years

Name (code for anonymity)	Length of Time Worked at Park	Do you Live in the Park?	Length of Time Lived in Park	WATER USES Drinking	Cooking	Showers	Bathroom	Cleaning	Washing Cars	Watering Lawns	Extra Treatment Used
A1	A	yes	A	yes	yes	yes	yes	yes	yes	no	
A12	A	yes	A	no	no	yes	yes	yes	yes	yes	Carbon/Distiller
A14	C	yes	C	no	no	yes	yes	yes	yes	yes	Softner
A15	B	yes	B	no	yes	yes	yes	yes	no	yes	
A16	A	yes	A	no	yes	yes	yes	yes	no	yes	Distiller
A17	B	yes	B	no	yes	yes	yes	yes	no	yes	
A2	D	yes	D	no	no	yes	yes	yes	yes	yes	Distiller
A8	A	yes	A	no	no	yes	yes	yes	no	yes	Distiller
B1	B	yes	B	no	no	yes	yes	yes	yes	yes	Carbon/Distiller
B2	D	yes	D	no	yes	yes	yes	no	yes	yes	Carbon/Distiller
B3	C	yes	C	no	yes	yes	yes	yes	yes	yes	
A10	D	no		yes	no	no	no	yes	no	yes	
A11	C	no		yes			yes				Distiller
A13	D	no		no	no	no	no	no	yes	no	
A18	D	no		no	yes	no	yes	yes	no	yes	
A3	D	no		yes	no	yes	yes	yes	yes	no	
A4	A	no		no	yes	no	yes	yes	no	yes	Boil for cooking
A5	D	no		no	no	no	yes	yes	no	no	
A6	D	no		no	no	no	yes	yes	no	no	
A7	B	no		yes	no	no	no	no	no	no	
A9	B	no		yes	no	no	yes	no	no	no	Distiller
B4	D	no		yes	no	no	yes	no	no	no	Distiller

Name (code for anonymity)	Other Sources of Water used	Water Quality Variation	Description of Objectionable Tastes and Odours	Acceptable at certian times of year ?	Times Worst
A1	None	Weekly/Monthly	Chlorine & swampy taste	Yes	Yes
A12		Worse in spring	Swampy, Organic, Imports taste to food, Chlorine high (periodically)		No
A14	Edmonton	Weekly	Terrible, red stains, odours	Quesionable	Yes
A15	Edmonton	Always bad	Sulfur	No	-
A16		Not noticed	Chlorine		-
A17	Edmonton	Daily, Chlorine	Chlorine & Swamp	Yes winter	Summer
A2	Outside	Monthly	Slough smell	No	Yes
A8		Weekly	Chlorine, brown colour		-
B1	Edmonton	Weekly, monthly, yearly	Chlorine, swampy, organic deposits	Marginal in winter	Yes
B2		Monthly & Daily with Chlorine dose	Chlorine, slough smell, objectionable taste, stomach upsets and foul	No	-
B3	Edmonton	Unsure	Musty, brown scum on boiling and stain on dish mat	Yes	
A10			Soda, film covering		-
A11			Slough	Yes	No
A13	Edmonton		Bad, terrible	No	Yes
A18	Edmonton		Tastes bad		-
A3		Monthly/Yearly	Chlorine/Slough smell	Yes-Less variation in winter	
A4	Outside		Stale (at gate)	N/A	N/A
A5	Outside for concession	Monthly (Hot & July)	Slough & Chlorine	N/A	Not in summer
A6		July & Aug poor quality	Slough taste	IMPLY OK	Not in summer
A7	Overflow campground	Yearly, worse this year	Slough & Chlorine, Brown	Yes	No
A9			Swampy	No	-
B4		Bad in spring	Yellow & stagnant	Not 100%	Spring

Elk Island Survey Results - August 1990 Survey
All Replies

* A = less than one year C = two to five years
B = one to two years D = over five years

Rating Given Water For Use
0 = Unnacceptable to 5 = Very Acceptable

Name (code for anoniaity)	Length of Time Worked at Park	Do you Live in the Park?	Length of Time Lived in Park	Do you use the current water	Drinking	Cooking	Showers	Bathroom	Cleaning	Washing Cars	Watering Lawns	Laundry	Confidence In Edm. Water
B1	C	Yes	C	Yes	1	3	4	5	5	5	5	3	2
B2	D	Yes	D	Yes	3	3	5	5	5	5	5		
B3	D	Yes	D	Yes	2		4	4	5	5	5	4	4
B4	D	No		Yes	4			4					1
C1	D	No	D	Same	3			5					4
C2	A	Yes	A	Yes	2	5	5	5	5	5	5	5	3
C3	A	Yes	A	More	1	2	3	3	3	3	3	3	
C4	D	No		Same	0			4					4
C5	D	No		Less	1	2		5	3	3	3		5
C6	B seasonal	Yes	A		0	2	3	5					4
C7	A	Yes	A		0	2	3	5	5			3	4
C8	A	Yes	A		2	3	5	5	5			5	5
C9	A	Yes	A		2	4	2	4	4	4	4	4	4
C10	D	No		Less	1			3					4
C11	B seasonal	No		Less				0					5
C12	A	No			1			5					5
C13	B	No		More	0		3	4	3				
C14	B seasonal	No											
C15	A	Yes	A	Same	1	4	3	4	5	5	5	4	1
C16	B	Yes	B	Yes	0	3	2	5	3	2	2	3	4
C17	A	Yes	A	Same	0	2	5	5	5	5	5		4

Name (code for anoniaity)	Extra Treatment Used	Other Sources of Water used	Water Quality Variation	Description of Objectionable Tastes and Odours	Acceptable Or Better than Normal at Times?	Times Worst
B1	Carbon		No	Musty	Consistant	
B2						
B3		Edmonton	Weekley, couple months (last winter) Cl fluctuated	Still distinct flavour	Not noticed	Last winter (chlorine)
B4	Distiller		Occational	Moldy smell	No	Spring
C1	Distiller		No	None		Spring - mabe
C2		Bottled		Swampy		
C3	Distiller		No pattern	Chlorine variation, better than last year		
C4			No	Slough smell	Better mid summer	Early summer
C5	Distiller	Other		Sour gas smell, swampy taste.		
C6	Distiller		No pattern	T&O like chlorinated lake water		No
C7	Distiller	Lake (for plants)		T&O like chlorinated lake water		In Feb. (chlorine)
C8	Distiller			Lake/slough T&O		
C9	Distiller			Chlorine		
C10			Weekly, different	Sour, smelly	No	Summer
C11		Edmonton				
C12				No	Unsure	
C13			Weekly, different	Odour & asthetic problems	Better, no pattern	
C14						
C15	Distiller		Chlorine change	Chemical taste	Not lately	Last fall
C16	Distiller			Chlorine, organics	No	
C17						

Name (code for anoniaity)	COMMENTS
B1	Great improvement
B2	
B3	Better if had been asked to monitor useage - more meaningful answers
B4	
C1	H.H.NOTE - I WNDER IF SHE HAS TASTED PARK WATER-OR JUST DISTILLED?
C2	Hev, could get used to it.
C3	
C4	
C5	IMPRESSION BAD COFFEE AT GOLF COURSE IS THIS PLANT FAULT
C6	Kills house plants
C7	Kills house plants
C8	
C9	
C10	
C11	DOESN'T USE
C12	
C13	
C14	DOESN'T USE
C15	
C16	You know what has to be done. Don't waste my time with surveys like this

Elk Island Water Evaluation Tests – Panel Odour Tests
July, August, 1988

Is this water acceptable? Describe odours or asthetic problems

SAMPLE GIVEN FOR TEST	person testing (code) B2	A2	A11	D1	D2	A6	D3	A9	D4	B3	D5	D6
RODI	yes	yes	yes	yes								
Edmonton	yes	yes	yes	yes								
Ozone	yes	yes	no/colour	no/cloudy								
Ozone with chlorine	yes	yes	yes	yes								
Ozone/Sand Filter	yes	yes	no/colour, acrid taste	no/cloudy								
Ozone/Sand Filter with chlorine	yes	yes	no/colour, after taste	no/odour								
RODI					yes	yes	yes	yes				
Edmonton					yes	yes	yes	yes				
Ozone/Carb Filter					yes	yes	yes	yes				
Ozone/Carb Filter with chlorine					no/?	yes	yes	yes				
Existing EI Plant (has chlorine)					no	no/chlorine	yes	yes				
RODI		yes	yes			yes	yes		yes			
Edmonton		yes	no/chlorine			no	yes		yes			
EI Plant Optimum		yes	ok/slight odour			no/chlorine	yes		yes			
EI Plant Optimum with chlorine		no/slough	no/slough			yes	yes		yes			
EI Optimum/Ozone		yes	yes			yes	yes		yes			
EI Optimum/Ozone with chlorine		yes	yes			no/skunky	yes		yes			
EI Opt/Ozone/Carb		yes	yes			yes	yes		yes			
EI Opt/Ozone/Carb with chlorine		no/chlorine	yes			no/chlorine	yes		yes			
RODI		yes	yes							yes	yes	yes
Edmonton		yes	yes							yes	yes	yes
EI Plant PreOzone		yes	yes							yes	yes	yes
EI Plant PreOzone with chlorine		no/chlorine	no/sloughy							no/musty	yes	no/chlorine
Alum/Ozone/Carb		yes	yes							no/metallic	yes/organic	yes
Alum/Ozone/Carb with chlorine		yes	no/soda							no/odour	yes	no/odour

10.7 Guidelines for Canadian Drinking Water Quality

10.7 TABLE OF CANADIAN DRINKING WATER GUIDELINES

Taken from "Guidelines for Canadian Drinking Water Quality - Fourth Edition", copyright 1989, Minister of Supply Services Canada.

MAC = Maximum acceptable concentrations
IMAC = Interim maximum acceptable concentrations
AO = Aesthetic objectives

Table 1

Parameter	MAC	IMAC	AO	Status
Aldicarb	0.009			
Aldrin + Dieldrin	0.0007			Under Review
Ammonia[1]				Proposed
Arsenic	0.05			Under Review
Asbestos[1]				
Atrazine		0.06		
Azinphos-methyl	0.02			
Barium		1.0		Proposed
Bendiocarb	0.04			
Benzene	0.005			
Benzo(a)pyrene	0.00001			
Boron	5.0			Under Review
Bromoxynil		0.005		
Cadmium	0.005			
Calcium[1]				Proposed
Carbaryl	0.09			
Carbofuran	0.09			
Carbon tetrachloride	0.005			
Chlordane	0.007			Under Review
Chloride			≤ 250	Proposed
Chlorpyrifos	0.09			
Chromium	0.05			
Colour			≤ 15 TCU	
Copper			≤ 1.0	Under Review

Parameter	MAC	IMAC	AO	Status
Cyanazine		0.01		
Cyanide	0.2			Under Review
Diazinon	0.02			
Dicamba	0.12			
Dichlorobenzene, 1,2-	0.2		≤ 0.003	
Dichlorobenzene, 1,4-	0.005		≤ 0.001	
Dichlorodiphenyltrichloroethane (DDT) + metabolites	0.03			Under Review
Dichloroethane, 1,2-		0.005		Proposed
Dichloromethane	0.05			
Dichlorophenol, 2,4-	0.9		≤ 0.0003	
Dichlorophenoxyacetic-acid, 2,4- (2,4-D)	0.1			Under Review
Diclofop-methyl	0.009			
Dimethoate		0.02		
Diquat	0.07			
Diuron	0.15			
Ethylbenzene			≤ 0.0024	
Fluoride[2]	1.5			Under Review
Gasoline[1]				
Glyphosate		0.28		
Hardness[3]				
Heptachlor + heptachlor epoxide	0.003			Under Review
Iron			≤ 0.3	Proposed
Lead[4]	0.01			Proposed

Parameter	MAC	IMAC	AO	Status
Lindane	0.004			Under Review
Magnesium[1]				Proposed
Malathion	0.19			
Manganese			≤ 0.05	Proposed
Mercury	0.001			
Methoxychlor	0.9			
Metolachlor		0.05		
Metribuzin	0.08			
Monochlorobenzene	0.08		≤ 0.03	Proposed
Nitrate[5]	45.0			Proposed
Nitrilotriacetic acid (NTA)	0.05			Under Review
Odour			inoffensive	
Paraquat		0.01		
Parathion	0.05			
Pentachlorophenol	0.06		≤ 0.03	
pH[6]			6.5–8.5	
Phorate		0.002		
Picloram		0.19		Proposed
Selenium	0.01			
Simazine		0.01		
Sodium[7]			≤ 200	Proposed
Sulphate[8]			≤ 500	Proposed
Sulphide (as H_2S)			≤ 0.05	Proposed
Taste			inoffensive	
Temephos		0.28		

Parameter	MAC	IMAC	AO	Status
Temperature			≤ 15°C	
Terbufos		0.001		
Tetrachlorophenol, 2,3,4,6-	0.1		≤ 0.001	
Toluene			≤ 0.024	
Total Dissolved Solids			≤ 500	Under Review
Triallate	0.23			
Trichloroethylene	0.05			Proposed
Trichlorophenol, 2,4,6	0.005		≤ 0.002	
Trichlorophenoxyacetic-acid, 2,4,5- (2,4,5-T)	0.28		≤ 0.02	
Trifluralin		0.045		Proposed
Trihalomethanes	0.35			Under Review
Turbidity[9,10]	1 NTU		≤ 5 NTU	
Uranium	0.1			
Xylenes			≤ 0.3	
Zinc			≤ 5.0	Proposed

10.8 <u>Log Sheet</u>

10.8 LOG SHEETS

Copy of operator log sheets supplied by AEC for operation of Administration site water treatment plant. Copies are reduced to 60% of size for purpose of this report.

ELK ISLAND WATER PLANT DAILY LOG

DATE	TIME	FLOW RATE l/min	FLOW METER READING m3	FLOW METER CHANGE m3	ALUM TANK LEVEL l	ALUM SOL'N USED l	AVERAGE ALUM DOSE mg/l	SODA ASH TANK LEVEL l	SODA ASH SOL'N USED l	AVERAGE SODA ASH DOSE mg/l	ALUM PUMP RATE ml/min	ALUM CURRENT DOSE mg/l	SODA ASH PUMP RATE ml/min	SODA ASH CURRENT DOSE mg/l	CL 2 METER SETTING

RATE = DOSE x FLOW - CONCENTRATION
mg/l mg/l l/min mg/ml

DOSE = CONCENTRATION x RATE - FLOW
mg/l mg/ml ml/min l/min

ALUM RATE = FLOW * DOSE / 50
ALUM DOSE = 50 * RATE / FLOW

AVE ALUM DOSE = ALUM USED * 50 * 1000 / METER CHANGE
AVE SODA ASH DOSE = SODA ASH USED * 25 * 1000 / METER CHANGE

SODA ASH RATE = FLOW * DOSE / 25
SODA ASH DOSE = 25 * RATE / FLOW

SVI'S				WATER QUALITY PARAMETERS												COMMENTS
				RAW			POST CLARIFIER	FILTERED WATER					TAP WATER			
	2	3	4	pH	TURBIDITY NTU	COLOUR CU	pH	pH	TURBIDITY NTU	COLOUR CU	CHLORINE mg/l	ODOUR	pH	CHLORINE mg/l		

10.9 AWWA Position on Home Treatment Devices

AWWA Position Statement on Home Water Treatment Devices

(As approved by the AWWA Board of Directors on January 29, 1990)

Taken from the April 1990 issue of the American Water Works Association publication PR Reservoir

Position

Home water treatment devices are not required to protect public health when consumers are receiving water from a public water supply system that meets state, provincial and federal health standards or regulations.

Rationale

Water utilities have a clear and continuing responsibility to inform consumers of the quality of drinking water being delivered and how the quality compares to the applicable state, provincial and federal quality standards and regulations.

Water supply sources have stringent test requirements before a new source of supply is provided to consumers. There should be comparable quality-control regulations for testing home water treatment devices before they are placed on the market.

Members of the home water treatment device industry have the responsibility to use accurate, responsible marketing techniques. Sales information should clearly describe the devices' capabilities and their significance.

All home water treatment devices require regular maintenance to function properly. Home water treatment devices that are not maintained and operated properly may degrade water quality. When consumers install a home water treatment device, they assume responsibility for proper use of the unit. The water utility cannot be held responsible for any degradation in water quality caused by a home treatment device.

Background

Environmental or public health regulatory agencies have not determined that home water treatment devices provide a demonstrated health benefit for consumers' drinking water which meets state, provincial and federal standards and regulations.

Alberta
ENVIRONMENTAL CENTRE